

Naval Facilities Engineering Command

200 Stovall Street
Alexandria, Virginia 22332-2300

APPROVED FOR PUBLIC RELEASE



Maintenance of Fire Protection Systems

**ARMY TM 5-695
NAVFAC MO-117
AIR FORCE AFM 91-37**

Departments of The Army, The Navy and The Air Force

September 1989



0525LP3201600

SNDL DISTRIBUTION:

A3 CNO

A6 CMC

(25 Copies each):

FKA1C COMNAVFACENGCOM

FKN1 EFDs

(10 copies each):

FA46 PWCLANT
FB54 PWCPAC

FKP7 NAVSHIPYDs
FT104 PWCCNET

HQ U.S. AIR FORCE
Engineering and Services Center
Tyndall AFB, FL 32403

U.S.ARMY
Office Chief of Engineers
Washington, DC 20314 (DAEN-MPO)

(2 copies each):

21A FLECOMINCH
22A FLECOM
23A NAVFORCOM
23C NAVRESFORDET
24G SUFORCOM
26B NAVSRESFORDET
26U SFORLANTREADSUPPGRU
26W CARGOHANDPORTGRU
26Z SHOREINTERMMMAINTACT
26NN LANTFLESCLSHIPENGTRATEAM
26VV SUFORREP
26XX OCEANU
39 CBREGIMDET
45H ENGBCO
45J HQB
B3 COLLEGE&UNIVERSITY
C20A ONRDET
C20B ONR
C20C NRLDET (Chesapeake Beach, Orlando Only)
C28E COMNAVBASDET
C31B NAVSTADET
C31F NAVFACDET
C31G NAVSHIPPREPFACDET
C34B NAVSTAROTADET
C34C NAVSUPPACTNAPLESDET
C40 NAVOCEANCOMDET(Only
Gulfport, Newport, FPO Seattle,)
C81C NAVOCEANSYSCENDET
C81D DAVTAYR&DCENDET
C84D NAVUSEAWARENGSTADET
E3A LABONR
E3C NORDA
FA7 NAVSTALANT
FA10 SUBASELANT
FA13 NAVSUBSUPPFACLANT
FA23 NAVFACLANT
FA32 CBULANT
FB10 NAVSTAPAC
FB13 SUBASEPAC
FB28 COMNAVBASEPAC
FB36 NAVFACPAC
FB41 CBUPAC
FB45 TRIREFFACPAC
FB48 NAVSUPPFACPAC
FC1 FOCCEUR
FC3 COMNAVACTEUR
FC5 NAVSUPPACTEUR
FC7 NAVSTAEUR

FC12 NAVSUPPOEUR
FD1 COMNAVOCEANCOM
FD4 OCEANCEN
FF1 COMNAVDIST Washington, DC
FF3 NAVSTACNO
FF18 NAVTACSUPPACT
FF32 FLDSUPPACT
FF38 USNA
FF42 NAVPGSCOL
FH1 COMNAVMECOM
FH3 NAVHOSP
FH30 NAVMEDCOMREG
FKA1 SYSCOMHQS
FKA8F2 NAVPRO
FKA8F5 SUBASE
FKN2 CBCs
FKN3 OICCs
FKN7 NEESA
FKN10 NAVSUPPFAC
FXN11 NAVCIVENGRLAB
FKP1B WPNSTAs
FKP1J NAVORDSTAs
FKP3A NAVPRO
FKP5A NAVSEACEN
FKQ6B NAVCOASTSYSCEN
FKQ6C NAVOCEANSYSCEN
FR15 NAVSUPPACTOMNAVRESFOR
FR18 NAVRESMAINTRAFAC
FT1 CNET
FT15 NAVU
FT18 CBU
FT20 NAVCONSTRACEN
FT24 FLETRACEN
FT28 N E T C
FT31 NTC
FT37 NAVSCOLCECOFF
FT38 NAVSUBTRACENPAC
FT39 NAVTECHTRACEN
FT55 NAVSCSCOL
FT60 EDTRASUPPCEN
FT78 NAVEDTRAPRODDEVCCEN
FT85 TRITRAFAC
V2 MARBKS
V12 CG MCDEC
V14 HQBN HQMC
V16 CG MCB (Less Oahu)
V17 MARCORCAMP
V23 CGMCLB

Additional copies may be obtained from:

Navy Publications and Forms Center
5801 Tabor Avenue
Philadelphia, PA 19120

ABSTRACT

This publication establishes standard practices and procedures for inspection, testing and maintenance of Fire Protection Systems at DOD installations. These practices and procedures are recommended to insure the safety of personnel and property. The contents include: foam, gaseous, and dry chemical extinguishing systems; and fire alarm, automatic sprinkler, standpipe, smoke control and fire resistance. In addition, this manual provides a glossary of terms, troubleshooting suggestions, and self-study questions.

ARMY TECHNICAL MANUAL
NO. TM 5-695
NAVY MAINTENANCE & OPERATION MANUAL
NO. NAVFAC MO-117
AIR FORCE MANUAL
NO. AFM 91-37

DEPARTMENTS OF THE ARMY,
THE NAVY AND THE AIR FORCE
Washington, D.C. February 1989

FOREWORD

This manual prescribes the policy, criteria, and procedures for maintaining fire protection systems at military installations. It establishes maintenance standards and provides guidance for the selection, use, and installation of foam, gaseous, dry chemical extinguishing systems and fire alarm, automatic sprinkler, and standpipe systems, as well as brief discussions on stairwell pressurization and fire resistance systems.

The maintenance standards prescribed have been established to protect personnel and Government property with an economical and effective expenditure of maintenance funds commensurate with the functional requirements of facilities. The publication furnishes guidance for the performance of work by maintenance forces in the field.

Self-Study Questions follow each chapter to assist activities in on-the-job training. An answer key is also provided. The rationale for the answers may be obtained from the appropriate military commands listed below.

The use of these systems and procedures by personnel responsible for maintenance service specifications, requisitions, procurement, inspection, storage, issue, application, and safety; should assure uniform, economical, and satisfactory maintenance. Advice concerning any procedure may be obtained from:

- (1) Department of the Army-U.S. Army Engineering and Housing Support Center (CEHSC-FB-I), Fort Belvoir, VA 22060-5580.
- (2) Department of the Navy-Naval Facilities Engineering Command (163) or its geographic Engineering Field Division (10).
- (3) Department of the Air Force-Directorate of Civil Engineering-HQ AFESC/DEM.

Recommendations or suggestions for modification, or additional information and instructions that will improve the publication and motivate its use, are invited and should be submitted through appropriate channels to the addresses listed above.

This publication supersedes the October 1981 editions of Army TM 5-695; Air Force AFM 91-37 and NAVFAC MO-117.

By order of the Secretaries of the Army, the Navy, and the Air Force.

Official:

R. L. DILWORTH
Brigadier General, U.S. Army
The Adjutant General

CARL E. VUONO
General, U.S. Army
Chief of Staff

LARRY D. WELCH
General, USAF
Chief of Staff

Official:

WILLIAM O. NATIONS
Colonel, USAF
Director of Information Management
and Administration

G. EVERHART
CAPT, CEC, U.S. Navy
For the Commander
Naval Facilities Engineering
Command

CONTENTS

	Page
ABSTRACT.	i
FOREWORD.	i i
LIST OF FIGURES.	x
LIST OF TABLES.	xiii
CHAPTER 1. INTRODUCTION.	1-1
1.1 PURPOSE.	1-1
1.2 SCOPE.	1-1
1.3 COOPERATION AND COORDINATION AMONG SERVICES	1-1
1.4 JOINT SERVICE RESPONSIBILITY	1-2
1.4.1 Army	1-2
1.4.2 Navy	1-2
1.4.3 Air Force.	1-2
1.5 MAINTENANCE STANDARDS, POLICIES, AND CRITERIA	1-2
1.6 MAINTENANCE PROGRAM.	1-3
1.6.1 Inspection.	1-3
1.6.2 Maintenance.	1-3
1.6.3 Repair.	1-5
1.7 SAFETY	1-4
1.8 TERMINOLOGY	1-4
1.9 IMPORTANCE OF MAINTENANCE	1-4
SELF-STUDY QUESTIONS.	1-7
CHAPTER 2. FIRE ALARM SYSTEMS.	2-1
2.1 GENERAL.	2-1
2.2 BUILDING ALARM SYSTEMS	2-1
2.2.1 Building Alarm System Types	2-1
2.2.2 Building Alarm System Components	2-6
2.2.3 Services for Building Alarm Systems	2-17
2.3 BASE ALARM SYSTEMS	2-24
2.3.1 Classification of Base Fire Alarm Systems	2-24
2.3.2 Base Alarm System Components	2-28
2.3.3 Services Provided by Base Alarm Systems	2-32
2.4 SUPERVISED CIRCUITS.	2-33
2.4.1 Classes, Types, and Applications of Supervision	2-33
SELF-STUDY QUESTIONS.	2-44

	Page
CHAPTER 3. INSPECTION, TESTING, AND MAINTENANCE OF FIRE ALARM SYSTEMS.	3-1
3.1 GENERAL MAINTENANCE	3-1
3.2 MAINTENANCE REFERENCE MATERIALS.	3-1
3.3 MAINTENANCE OF COMMON COMPONENTS	3-3
3.3.1 Relays.	3-3
3.3.2 Resistors	3-4
3.3.3 Capacitors.	3-4
3.3.4 Diodes.	3-5
3.3.5 Transformers.	3-7
3.3.6 Fuses/Circuit Breakers.	3-9
3.3.7 Control Panel Switches.	3-10
3.3.8 Motors.	3-10
3.3.9 Lamps/Visual Indicators	3-12
3.3.10 Wiring.	3-13
3.3.11 Meters.	3-14
3.4 TYPICAL MAINTENANCE CHARACTERISTICS OF CERTAIN EQUIPMENT. . .	3-15
3.4.1 Building Alarm Systems.	3-15
3.5 GENERAL PROCEDURES--TESTING AND MAINTENANCE OF CONTROL AND AUXILIARY UNITS	3-26
3.5.1 Frequency.	3-26
3.5.2 Procedure.	3-26
3.5.3 Troubleshooting Circuit Faults.	3-26
3.5.4 Indicating Circuit Faults	3-37
3.5.5 Wire Pulling.	3-42
3.6 FIRE ALARM INITIATING DEVICES	3-42
3.6.1 Manual Fire Alarms.	3-42
3.6.2 Automatic Fire Alarm Initiating Devices	3-44
3.6.3 Smoke Actuated Detectors.	3-50
3.6.4 Flame Actuated Detectors.	3-55
3.6.5 Sprinkler Waterflow Actuated Detectors.	3-60
3.7 SUPERVISORY ALARM INITIATING DEVICES.	3-65
3.7.1 Valve Position Supervisory Devices.	3-65
3.7.2 Water Level Supervisory Devices	3-67
3.7.3 Electric Fire Pump Supervisory Devices.	3-69
3.7.4 Engine-Driven Fire Pump Supervisory Devices	3-70
3.7.5 Temperature Supervisory Devices	3-72
3.7.6 Air Pressure Supervisory Devices.	3-73
3.7.7 Other Supervisory Devices	3-76
3.8 ALARM INDICATING DEVICES	3-76
3.8.1 Visual Alarm Indicators	3-76
3.8.2 Audible Alarm Indicators.	3-77
3.9 CONNECTION OF BUILDING ALARM TO BASE ALARM SYSTEM	3-79
3.9.1 Signals Transmitted to Base Alarm Headquarters.	3-80
3.9.2 Connection to Noncoded Base Alarm System.	3-80
3.9.3 Connection to Coded Base Alarm System	3-80
3.9.4 Bypassing Base Alarm Connection for Building-Alarm System Testing.	3-80
3.10 BASE ALARM SYSTEM EQUIPMENT	3-81

	Page
3.10.1 Connection to Building Alarm System.	3-81
3.10.2 Direct Connection to Fire Alarm and Supervisory Devices.	3-81
3.10.3 Base Alarm System Circuits	3-81
3.10.4 Transmitters.	3-84
3.10.5 Signal Receiving Devices	3-85
3.10.6 Signal Recording Devices	3-85
3.10.7 Power Supplies.	3-86
SELF-STUDY QUESTIONS.	3-88
CHAPTER 4. AUTOMATIC SPRINKLER AND STANDPIPE SYSTEMS	4-1
4.1 AUTOMATIC SPRINKLER SYSTEMS	4-1
4.1.1 Sprinklers.	4-1
4.1.2 Types of Sprinkler Systems.	4-6
4.1.3 Piping Materials.	4-19
4.1.4 Local Alarms for Sprinkler Systems.	4-20
4.2 STANDPIPE SYSTEMS.	4-21
4.2.1 Classification of Standpipe Systems	4-21
4.2.2 Types of Standpipe Systems.	4-21
4.3 WATER SUPPLIES FOR SPRINKLER AND STANDPIPE SYSTEMS.	4-21
4.3.1 Public (or Base) Water Supplies	4-22
4.3.2 Water Tanks.	4-23
4.3.3 Fire Pumps.	4-29
4.3.4 Control Valves.	4-38
4.3.5 Check Valves, Waterflow Meters, and Backflow Preventers	4-39
4.3.6 Automatic Pressure Regulating Valves.	4-44
SELF-STUDY QUESTIONS.	4-46
CHAPTER 5. INSPECTION, TESTING, AND MAINTENANCE OF AUTOMATIC SPRINKLER AND STANDPIPE SYSTEMS	5-1
5.1 GENERAL INFORMATION	5-1
5.2 AUTOMATIC SPRINKLERS	5-1
5.3 OUTSIDE OPEN SPRINKLERS	5-4
5.4 PIPING AND HANGERS	5-4
5.5 OBSTRUCTED PIPING	5-4
5.6 FLUSHING SPRINKLER SYSTEMS	5-5
5.6.1 Hydraulic Method.	5-5
5.6.2 Hydropneumatic Method	5-6
5.6.3 Mechanical Method	5-6
5.7 ALARM CHECK VALVES.	5-6
5.8 DRY PIPE VALVES AND AIR CHECK VALVES	5-7
5.9 ANTIFREEZE SYSTEMS.	5-11
5.10 DELUGE AND PRE-ACTION VALVES.	5-11
5.11 HIGH SPEED SUPPRESSION SYSTEM	5-12

	Page
5.12 STANDPIPE AND HOSE CONNECTIONS.	5-12
5.13 INTERRUPTIONS TO SPRINKLER AND STANDPIPE SYSTEM PROTECTION.	5-13
5.14 CLOSING CONTROL VALVES IN EMERGENCY	5-13
5.15 DEACTIVATING AUTOMATIC SPRINKLER SYSTEMS.	5-13
5.16 CONVERTING AUTOMATIC SPRINKLER SYSTEMS.	5-14
5.17 RESTORING AUTOMATIC SPRINKLER SYSTEM SERVICE.	5-15
5.18 WATER SUPPLIES FOR SPRINKLER AND STANDPIPE SYSTEMS.	5-16
5.18.1 Water Mains.	5-16
5.18.2 Fire Hydrants.	5-17
5.18.3 Fire Department Connections.	5-18
5.18.4 Water Tanks.	5-18
5.18.5 Fire Pumps.	5-21
5.18.6 Sprinkler Control Valves	5-28
5.18.7 Check Valves, Waterflow Meters, and Backflow Preventers.	5-29
SELF-STUDY QUESTIONS.	5-31
 CHAPTER 6. FOAM EXTINGUISHING SYSTEMS.	 6-1
6.1 GENERAL.	6-1
6.1.1 Protection Considerations	6-2
6.2 LOW EXPANSION FOAM SYSTEMS	6-3
6.2.1 Proportioning Methods	6-3
6.2.2 Foam Makers.	6-7
6.3 HIGH EXPANSION FOAM SYSTEMS	6-9
6.3.1 Foam Concentrates	6-10
6.3.2 Foam Generators	6-10
6.4 ASSOCIATED ALARM SYSTEMS	6-11
6.4.1 Initiating Devices.	6-12
6.4.2 Circuit Arrangement and Function.	6-12
6.4.3 Alerting Devices.	6-12
SELF-STUDY QUESTIONS.	6-13
 CHAPTER 7. INSPECTION, TESTING, AND MAINTENANCE OF FOAM SYSTEMS.	 7-1
7.1 LOW EXPANSION FOAM SYSTEMS	7-2
7.2 HIGH EXPANSION FOAM SYSTEMS	7-2
7.3 FOAM QUALITY	7-3
7.3.1 Foam Concentrate.	7-3
7.3.2 Foam Solution	7-3
7.3.3 Foam.	7-4
7.4 ASSOCIATED ALARM SYSTEMS	7-4
7.4.1 Electrical Release Devices.	7-4
7.4.2 Cross Zoning.	7-4
SELF-STUDY QUESTIONS.	7-5

	Page
CHAPTER 8. GASEOUS EXTINGUISHING SYSTEMS	8-1
8.1 GENERAL.	8-1
8.1.1 Local Application Systems	8-1
8.1.2 Total Flooding Systems.	8-1
8.1.3 Hose Line Systems	8-1
8.2 CARBON DIOXIDE SYSTEMS	8-1
8.2.1 High Pressure Systems	8-2
8.2.2 Low Pressure Systems.	8-3
8.2.3 Comparison of Low and High Pressure Systems	8-4
8.2.4 Operating Devices	8-4
8.2.5 Piping.	8-5
8.2.6 Nozzles.	8-6
8.2.7 Total Flooding Systems.	8-6
8.2.8 Local Application Systems	8-7
8.2.9 Hose Line Systems	8-7
8.3 HALOGENATED GAS SYSTEMS.	8-8
8.3.1 Characteristics of Halon 1301 and Halon 1211.	8-9
8.3.2 Storage.	8-9
8.3.3 Operating Devices	8-9
8.3.4 Piping.	8-11
8.3.5 Nozzles.	8-11
8.4 ASSOCIATED ALARM SYSTEMS	8-12
8.4.1 Initiating Devices.	8-13
8.4.2 Circuit Arrangement and Function.	8-13
8.4.3 Alerting Devices.	8-14
SELF-STUDY QUESTIONS.	8-15
CHAPTER 9. INSPECTION, TESTING, AND MAINTENANCE OF GASEOUS SYSTEMS . .	9-1
9.1 CARBON DIOXIDE SYSTEMS	9-1
9.1.1 High Pressure Systems	9-1
9.1.2 Low Pressure Systems.	9-2
9.2 HALOGENATED SYSTEMS	9-3
9.3 ASSOCIATED ALARM SYSTEM	9-4
9.3.1 Release Devices and Auxiliary Functions	9-4
9.3.2 Cross Zoning.	9-5
9.3.3 Abort Feature	9-5
SELF-STUDY QUESTIONS.	9-6
CHAPTER 10. DRY AND WET CHEMICAL EXTINGUISHING SYSTEMS.	10-1
10.1 GENERAL.	10-1
10.1.1 Types of Systems.	10-4
10.1.2 System Components	10-5
10.2 ASSOCIATED ALARM SYSTEMS.	10-5

(Contents, continued)

	Page
10.2.1 Electrical Initiating Devices.	10-6
10.2.2 Circuit Arrangement and Function	10-6
10.2.3 Alerting Devices.	10-6
SELF-STUDY QUESTIONS.	10-7
CHAPTER 11. INSPECTION, TESTING, AND MAINTENANCE OF DRY AND WET CHEMICAL SYSTEMS.	11-1
11.1 GENERAL.	11-1
11.2 DRY AND WET CHEMICAL SYSTEM HARDWARE	11-2
11.3 ASSOCIATED ALARM SYSTEMS	11-2
11.3.1 Release Devices and Auxiliary Functions.	11-2
11.3.2 Special Features	11-2
11.3.3 Troubleshooting.	11-2
SELF-STUDY QUESTIONS.	11-3
CHAPTER 12. OTHER FIRE PROTECTION SYSTEMS.	12-1
12.1 GENERAL.	12-1
12.2 SMOKE CONTROL SYSTEMS	12-1
12.2.1 Stairwill Pressurization Systems	12-1
12.2.2 Zoned Smoke Control Systems.	12-3
12.2.3 Testing and Maintenance.	12-4
12.3 FIRE RESISTANT ASSEMBLIES	12-4
12.3.1 Protection of Single Structural Members.	12-4
12.3.2 Fire Walls.	12-5
12.3.3 Fire Doors.	12-5
12.3.4 Fire Dampers.	12-5
SELF-STUDY QUESTIONS.	12-6
ANSWER KEY. . . . .	.Key-1
GLOSSARY	Glossary-1
INDEX	Index-1

LIST OF FIGURES

<u>FIGURE NO.</u>	<u>TITLE</u>	<u>PAGE</u>
2-1	CONTROL UNIT WITH ANNUNCIATION	2-2
2-2	REMOTE ANNUNCIATOR (WEATHERPROOF).	2-2
2-3	PAPER TAPE RECORDER.	2-4
2-4	ALARM CONSOLE WITH ALPHA-NUMERIC RECORDER AND CRT DISPLAY. .	2-5
2-5	LOCAL FIRE ALARM SYSTEM DIAGRAM.	2-7
2-6	SHUNT NONINTERFERING CODED ALARM SIGNALING CIRCUIT	2-10
2-7	SERIES NONINTERFERING CODED ALARM SIGNALING CIRCUIT.	2-11
2-8	AUDIBLE SIGNAL APPLIANCES.	2-12
2-9	TYPICAL DC POWER SUPPLY AND BATTERY CHARGER	2-14
2-10	TYPICAL FAN SHUTDOWN CIRCUIT	2-16
2-11	ELECTROMAGNETIC DOOR HOLDER.	2-16
2-12	MANUAL PULL BOX.	2-17
2-13	OS&Y VALVE POSITION SWITCH (PLUNGER-TYPE).	2-19
2-14	OS&Y VALVE POSITION SWITCH (LEVEL-TYPE).	2-19
2-15	LOW AIR TEMPERATURE SWITCH	2-20
2-16	PIV POSITION SWITCH (PLUNGER-TYPE)	2-20
2-17	PIV POSITION SWITCH (LEVEL-TYPE)	2-20
2-18	BUTTERFLY VALVE POSITION SWITCH (MAGNETICALLY OPERATED). . .	2-21
2-19	BUTTERFLY VALVE POSITION SWITCH (MECHANICALLY OPERATED). . .	2-21
2-20	NON-RISING STEM VALVE POSITION SWITCH.	2-22
2-21	WATER LEVEL SWITCH (FLOAT ACTUATED).	2-22
2-22	LOW WATER TEMPERATURE SWITCH	2-22
2-23	GATE VALVE POSITION SWITCH (PLUG-TYPE)	2-22
2-24	CLASS B SIGNAL INITIATING CIRCUIT.	2-23
2-25	MULTIPLEX ALARM SYSTEM BLOCK DIAGRAM	2-26
2-26	CLASS B REMOTE SIGNALING CIRCUIT	2-29
2-27	McCULLOH SIGNAL RECEIVING EQUIPMENT.	2-30
2-28	RADIO CALL BOX SIGNAL RECEIVER CONSOLE	2-31
2-29	CLASS B ALARM INDICATING CIRCUIT	2-35
2-30	CLASS A ALARM INITIATING CIRCUIT	2-36
2-31	CLASS A REMOTE SIGNALING CIRCUIT (McCULLOH).	2-38
2-32	CLASS A ALARM INDICATING CIRCUIT	2-39
2-33	SERIES NORMALLY CLOSED INITIATING CIRCUIT.	2-40
2-34	EXAMPLE OF AN UNSUPERVISED INITIATING CIRCUIT.	2-41
2-35	SERIES INDICATING CIRCUIT.	2-42
2-36	EXAMPLE OF POWER SUPERVISION	2-43
3-1	CAPACITOR CHECKING METHOD.	3-6
3-2	DIODE BRIDGE CHARGING CIRCUIT AND RESISTANCE CHECKING METHOD	3-8
3-3	AMMETER CHECKING METHOD.	3-16
3-4	McCULLOH CODING CONTACT ADJUSTMENT	3-23
3-5	McCULLOH CODE WHEEL WITH DOUBLE TOOTH SPACING.	3-24
3-6	McCULLOH CODE WHEEL WITH NORMAL TOOTH SPACING.	3-25
3-7	TROUBLESHOOTING CHART FOR POWER CIRCUIT OPEN FAULT	3-28
3-8	TROUBLESHOOTING CHART FOR A SHORT CIRCUIT FAULT IN AN UNSUPERVISED INITIATING CIRCUIT.	3-29
3-9	TROUBLESHOOTING CHART FOR POWER CIRCUIT GROUND FAULT	3-30

<u>FIGURE NO.</u>	<u>TITLE</u>	<u>PAGE</u>
3-10	TROUBLESHOOTING CHART FOR A SHORT CIRCUIT FAULT IN A POWER CIRCUIT.	3-31
3-11	TROUBLESHOOTING CHART FOR AN OPEN CIRCUIT FAULT IN A SERIES NORMALLY CLOSED CIRCUIT	3-33
3-12	CODED FIRE ALARM BOX.	3-43
3-13	LOW PROFILE HEAT DETECTOR.	3-45
3-14	REPLACEABLE ELEMENT FIXED TEMPERATURE HEAT DETECTOR.	3-45
3-15	COMBINATION FIXED TEMPERATURE/RATE OF RISE HEAT DETECTOR	3-45
3-16	RATE COMPENSATED HEAT DETECTOR	3-45
3-17	TYPICAL ARRANGEMENT OF PHOTOELECTRIC SMOKE DETECTOR COMPONENTS.	3-50
3-18	IONIZATION SMOKE DETECTOR.	3-51
3-19	DUCTTYPE IONIZATION SMOKE DETECTOR	3-52
3-20	INFRARED FLAME DETECTORS	3-56
3-21	ULTRAVIOLET FLAME DETECTORS.	3-57
3-22	PRESSURE INCREASE TYPE WATERFLOW DETECTOR.	3-60
3-23	VANE TYPE WATERFLOW DETECTOR	3-61
3-24	FIXED PRESSURE WATERFLOW DETECTOR WITH PUMP.	3-62
3-25	ELECTRONIC PRESSURE DROP WATERFLOW DETECTOR.	3-63
3-26	OS&Y VALVE POSITION SUPERVISORY SWITCH INSTALLATION.	3-66
3-27	PIV VALVE POSITION SUPERVISORY SWITCH INSTALLATION	3-66
3-28	INSTALLATION OF WATER LEVEL AND WATER TEMPERATURE SUPERVISORY DEVICES.	3-68
4-1	SPRINKLER DEFLECTOR STYLES	4-1
4-2	FUSIBLE LINK AUTOMATIC SPRINKLER	4-2
4-3	FRANGIBLE BULB AUTOMATIC SPRINKLER	4-4
4-4	FRANGIBLE PELLET AUTOMATIC SPRINKLER	4-4
4-5	BI-METALLIC ELEMENT AUTOMATIC SPRINKLER.	4-4
4-6	DRY PENDENT AUTOMATIC SPRINKLER.	4-4
4-7	OPEN SPRINKLERS.	4-5
4-8	WATER SPRAY NOZZLES.	4-5
4-9	ALARM CHECK VALVE.	4-6
4-10	ALARM CHECK VALVE (SECTION).	4-7
4-11	DRY PIPE VALVE.	4-7
4-12	DIFFERENTIAL DRY PIPE VALVE.	4-8
4-13	DRY PIPE SYSTEM ACCELERATOR	4-9
4-14	DRY PIPE SYSTEM EXHAUSTER.	4-10
4-15	LOW DIFFERENTIAL DRY PIPE VALVE.	4-10
4-16	AIR PRESSURE MAINTENANCE DEVICE.	4-11
4-17	MECHANICAL DRY PIPE VALVE.	4-11
4-18	ANTIFREEZE SYSTEM.	4-11
4-19	DELUGE SYSTEM.	4-13
4-20	DELUGE VALVE (VIKING MODEL D-4),	4-14
4-21	DELUGE VALVE (AUTOMATIC SPRINKLER MODEL C)	4-14
4-22	RATE OF RISE DETECTION COMPONENTS.	4-15
4-23	SEPARATION OF H.A.D. GROUPS BY MERCURY CHECKS.	4-15
4-24	SPRINKLER PRE-PRIME PLUGS.	4-16
4-25	COMBINED SYSTEM HEADER ARRANGEMENT	4-17
4-26	EXPLOSIVE OPERATED DELUGE VALVE (GRINNELL PRIMAC MODEL B-2).	4-18
4-27	PILOT OPERATED NOZZLE SYSTEM (AUTOMATIC SPRINKLER PILOTEX)	4-19
4-28	WATER MOTOR ALARM.	4-20
4-29	DRY BARREL FIRE HYDRANT.	4-22
4-30	WET BARREL FIRE HYDRANT.	4-22
4-31	FIRE DEPARTMENT CONNECTION	4-23

<u>FIGURE NO.</u>	<u>TITLE</u>	<u>PAGE</u>
4-32	GRAVITY TANKS	4-24
4-33	SUCTION TANK	4-25
4-34	PRESSURE TANK	4-26
4-35	GRAVITY CIRCULATION TANK HEATING SYSTEM.	4-27
4-36	FORCED CIRCULATION TANK HEATING SYSTEM	4-28
4-37	VERTICAL RADIATOR TANK HEATING SYSTEM.	4-29
4-38	HORIZONTAL SHAFT CENTRIFUGAL FIRE PUMP INSTALLATION.	4-30
4-39	VERTICAL SHAFT TURBINE FIRE PUMP INSTALLATION.	4-30
4-40	CHARACTERISTIC CURVES OF HORIZONTAL AND VERTICAL SHAFT FIRE PUMPS.	4-31
4-41	PITOT TUBE.	4-32
4-42	FLOW METER INSTALLATION.	4-32
4-43	HORIZONTAL SPLIT-CASE CENTRIFUGAL FIRE PUMP.	4-33
4-44	VERTICAL SHAFT TURBINE FIRE PUMP	4-35
4-45	ELECTRIC MOTOR DRIVEN FIRE PUMP.	4-36
4-46	FIRE PUMP MOTOR CONTROLLER	4-36
4-47	ENGINE DRIVEN FIRE PUMP.	4-36
4-48	ENGINE COOLING WATER ARRANGEMENT	4-36
4-49	FUEL SYSTEM FOR DIESEL ENGINE DRIVEN FIRE PUMP	4-36
4-50	INTERNAL COMBUSTION ENGINE FIRE PUMP CONTROLLER.	4-37
4-51	KEY-OPERATED CONTROL VALVE	4-38
4-52	POST INDICATOR VALVES...	4-38
4-53	OS&Y GATE VALVE.	4-39
4-54	SWING CHECK VALVE.	4-40
4-55	WAFFER CHECK VALVE.	4-41
4-56	DOUBLE CHECK VALVE INSTALLATION.	4-41
4-57	DETECTOR CHECK VALVE WITH METER IN BY-PASS	4-42
4-58	PROPORTIONAL TYPE FULL REGISTRATION WATER METER.	4-42
4-59	DISPLACEMENT TYPE FULL REGISTRATION WATER METER.	4-43
4-60	TURBO TYPE FULL REGISTRATION WATER METE.	4-43
4-61	REDUCED PRESSURE BACKFLOW PREVENTER.	4-43
4-62	DIRECT ACTING LEVER OPERATED FLOAT VALVE	4-44
4-63	DOUBLE ACTING ALTITUDE VALVE . . ,	4-44
4-64	SINGLE ACTING ALTITUDE VALVE	4-45
4-65	PRESSURE-REDUCING VALVE.	4-45
4-66	PRESSURE-RELIEF VALVE.	4-45
6-1	LINE PROPORTIONER INSTALLATION	6-4
6-2	PRESSURE PROPORTIONER INSTALLATION	6-4
6-3	BLADDER TANK AND HOSE REEL SYSTEM.	6-5
6-4	BALANCED PRESSURED PROPORTIONER INSTALLATION	6-6
6-5	AROUND-THE-PUMP PROPORTIONER INSTALLATION.	6-7
6-6	MONITOR-MOUNTED FOAM NOZZLE.	6-7
6-7	FOAM CHAMBER ASSEMBLY.. . . .	6-8
6-8	FOAM WATER SPRINKLERS.. . . .	6-9
6-9	HIGH BACK PRESSURE FOAM MAKER.	6-9
6-10	TYPICAL HIGH BACK PRESSURE FOAM DISCHARGE CONNECTIONS AT TANK.	6-10
6-11	ASPIRATING TYPE HIGH EXPANSION FOAM GENERATOR.	6-10
6-12	BLOWER TYPE HIGH EXPANSION FOAM GENERATOR.	6-11
8-1	PRESSURE IN CARBON DIOXIDE CYLINDERS AT VARIOUS TEMPERATURES.	8-2
8-2	TYPICAL CYLINDER ARRANGEMENT FOR HIGH PRESSURE CARBON DIOXIDE SYSTEM.	8-2

<u>FIGURE NO.</u>	<u>TITLE</u>	<u>PAGE</u>
8-3	REFRIGERATED LOW PRESSURE CARBON DIOXIDE STORAGE TANK. . . .	8-3
8-4	CARBON DIOXIDE CONTROL AND RELEASE PORTION	8-5
8-5	CARBON DIOXIDE PNEUMATIC CONTROL HEAD.	8-5
8-6	CARBON DIOXIDE ELECTRIC CONTROL HEAD	8-6
8-7	CARBON DIOXIDE NOZZLES	8-6
8-8	TOTAL FLOODING CARBON DIOXIDE SYSTEM INSTALLATION.	8-7
8-9	LOCAL APPLICATION CARBON DIOXIDE SYSTEM INSTALLATION	8-8
8-10	CARBON DIOXIDE HOSE LINE SYSTEM INSTALLATION	8-8
8-11	TOTAL FLOODING HALON SYSTEM.	8-10
8-12	HALON STORAGE CONTAINERS	8-11
8-13	HALON NOZZLES.	8-11
8-14	SELF-CONTAINED HALON SYSTEM.	8-12
9-1	BEAM SCALE PORTABLE CYLINDER WEIGHING DEVICE	9-2
10-1	TOTAL FLOODING DRY CHEMICAL SYSTEM INSTALLATION	10-1
10-2	LOCAL APPLICATION DRY CHEMICAL SYSTEM INSTALLATION.	10-2
10-3	RESTAURANT RANGE HOOD WET CHEMICAL SYSTEM	10-2
10-4	STORED PRESSURE DRY CHEMICAL CYLINDER WITH HOSE LINE. . . .	10-3
10-5	DRY CHEMICAL AND EXPELLENT GAS STORAGE CYLINDERS WITH PIPING CONNECTION.	10-4
10-6	DOUBLE CYLINDER STORED PRESSURE DRY CHEMICAL SYSTEM	10-4
12-1	DIAGRAM OF TOP INJECTION STAIRWELL PRESSURIZATION SYSTEM. .	12-2
12-2	DIAGRAM OF BOTTOM INJECTION STAIRWELL PRESSURIZATION SYSTEM	12-2
12-3	MULTIPLE INJECTION SYSTEM WITH AN EXHAUST FAN AND SEVERAL WALL MOUNTED SUPPLY FANS.	12-2
12-4	MULTIPLE INJECTION SYSTEM WITH AN EXHAUST FAN AND A ROOF MOUNTED SUPPLY FAN.	12-2
12-5	COMPARTMENTALIZATION OF STAIRWELL IN THE IDS CENTER IN MINNEAPOLIS.	12-3
12-6	FIRE PROTECTION FOR STEEL COLUMNS	12-4

LIST OF TABLES

<u>TABLE NO.</u>	<u>TITLE</u>	<u>PAGE</u>
1-1	AUTOMATIC SPRINKLER PERFORMANCE SUMMARY, 1925-1969	1-5
1-2	DETAILED ANALYSIS OF UNSATISFACTORY AUTOMATIC SPRINKLER PERFORMANCE.	1-6
2-1	ACTIONS REQUIRED TO RESTORE ALARM SYSTEM TO NORMAL OPERATING CONDITION.	2-8
3-1	SUMMARY OF INSPECTION AND TEST FREQUENCIES FOR ALARM SYSTEMS.	3-2
4-1	SPRINKLER TEMPERATURE RATINGS.	4-2
4-2	ANTIFREEZE SOLUTIONS	4-12
5-1	SUMMARY OF INSPECTION AND TEST FREQUENCIES FOR SPRINKLER AND STANDPIPE SYSTEMS.	5-2
5-2	SPARE SPRINKLER SUPPLIES.	5-3
5-3	DIFFERENTIAL DRY PIPE VALVE AIR PRESSURE SPECIFICATIONS. . .	5-9
5-4	FIRE PUMP TROUBLES AND CAUSES	5-23
7-1	SUMMARY OF INSPECTION AND TEST FREQUENCIES FOR FOAM SYSTEMS.	7-1
9-1	SUMMARY OF INSPECTION AND TEST FREQUENCIES FOR GASEOUS SYSTEMS.	9-1
11-1	SUMMARY OF INSPECTION AND TEST FREQUENCIES FOR DRY AND WET CHEMICAL SYSTEMS	11-1

CHAPTER 1. INTRODUCTION

1.1 PURPOSE. This manual is a guide for military and civilian personnel who are concerned with the operation, testing, inspection, and maintenance of fire protection systems.

1.2 SCOPE. This manual describes the operation, testing, and maintenance of fire alarm and fire extinguishing systems for buildings and other structures. Fire alarm and fire extinguishing systems-described in this manual include:

- Fire detection and notification equipment for local, remote station, proprietary, and central station alarm systems
- Automatic sprinkler systems
- Standpipe and hose systems
- Foam extinguishing systems
- Gaseous extinguishing systems
- Chemical extinguishing systems

This document is intended to serve as both an educational reference and a manual. Beginning with Chapter 2, the reader will be provided with a general description of each type of fire protection system. Included in each chapter is a description of the testing, inspection and maintenance procedures for the previously described fire protection system. Self-instructional questions are presented at the end of each chapter for those readers using this document as a textbook.

Because of the large number of manufacturers and models for a given fire protection product, this manual cannot be considered to be applicable in every detail to a particular device or system. Rather, the principles apply on a generic basis for any given device or system.

The procedures included in this manual for the testing of fire protection systems do not necessarily constitute procedures for acceptance tests of new fire protection systems. Procedures for acceptance tests of new fire protection systems are included in applicable design standards. In all cases, the operating, testing, and maintenance procedures for fire protection equipment should be done according to the manufacturer's instructions.

1.3 COOPERATION AND COORDINATION AMONG SERVICES. Cooperation and coordination among services and departments in fire protection testing and maintenance are encouraged at all levels of command. Major commands and installations in a geographical area should establish and maintain liaison and cross-service assistance for most economical and efficient servicing. Inspecting, testing and maintenance must be continuous to avoid unnecessary interruptions and possible danger to personnel.

1.4 JOINT SERVICE RESPONSIBILITY. The responsible organization and point of contact for latest available information, specifications, and procedures for each branch of service is as follows:

1.4.1 Army. Staff, command, and technical responsibility for maintenance and repair of fire protection systems at Army installations will conform to assignments set forth in AR-420-90. Maintenance and repair support is the responsibility of the installation facilities engineer. Requests for assistance should be forwarded through channels to the Office of the Chief of Engineers, HQ, DA, DAEN-MPO-B, Washington, DC 20314.

1.4.2 Navy. The Commanding Officer at each Naval shore installation is responsible for an adequate maintenance program. These responsibilities may be delegated to Fire Departments and Public Works Centers or Public Works Departments as appropriate. The maintenance program shall include, but is not limited to:

- Inspections and surveys to determine and identify defective conditions (Reference NAVFAC MO-322 for guidelines)
- Preventive maintenance according to standards set in this manual
- Inspections and instructions to ensure that labor, materials, and equipment are used properly and safely and that operations are planned and supervised by qualified personnel
- Coordination with civilian and other governmental agencies that have similar operation and maintenance capabilities
- Training and qualifying personnel to perform effective maintenance

Technical support for inspection, maintenance, repair condition assessment, and operation of fire protection systems is available at Naval Facilities Engineering Command Headquarters, Code 16 or Engineering Field Divisions - Facilities Division, Code 10.

1.4.3 Air Force. Policy and standards for the design of fire protection systems are established in AFM 88-10, Ch. 6 and AFR 88-15. AFR 92-1 deals with the fire protection program. The commanding officer at each installation is responsible for an adequate maintenance program. Assistance is available from HQ Air Force Engineering and Services Center (HQ AFESC/DEMM) Tyndall AFB FL 32403-6001.

1.5 MAINTENANCE STANDARDS, POLICIES, AND CRITERIA. The standards or criteria contained in this manual have been developed by the Army, Navy, -and Air Force with the concurrence and approval of the Department of Defense (DOD). These standards address the inspection and maintenance of fire protection systems at military installations. Compliance with these standards is mandatory for the Army and the Navy. It will adequately support the operational missions of the installations, and will permit interservice assistance and support, where possible, in the interest of efficiency and economy.

Determining the need and performing maintenance, repairs, and rehabilitation of existing fire protection systems should be based on

experience, judgment, and/or engineering evaluation. When systems are inactive, maintenance policies should be consistent with the anticipated future mission of the installation and in accordance with the inactivation plan. Qualified technical personnel should be used to assist in the establishment of inspection and maintenance programs.

Requirements for the design and construction of fire protection systems are found in various departmental publications. Reference to other published materials which provide related or more extensive information on specific areas of maintenance is made where appropriate throughout this manual.

1.6 MAINTENANCE PROGRAM. An inspection and maintenance program for fire protection systems should be developed according to regulations and policy of each branch of service. The objectives of the Maintenance Program are: 1) prevention or prompt detection of deficiencies or damage, 2) prompt maintenance or repairs in an economical and workable manner, and 3) avoidance of unnecessary interruptions and possible danger to personnel, facilities and missions. Damaged parts should be replaced or repaired as soon as possible because when one item is not working, the entire system may not function as expected or required.

A maintenance program consists of three tasks: inspection, maintenance and repair. The following should be considered in developing and implementing the maintenance program.

1.6.1 Inspection. Inspections should be conducted to determine the degree of fire hazard involved with each structure. The degree of hazard will be used to determine the priority sequence of repair and the extent of repair required. Visual and mechanical checking of the condition of facilities should be performed on a regularly scheduled basis to determine the extent of the maintenance and repair work required and to ensure the proper operation of the systems. Additional inspections may be necessary under certain circumstances, such as heavy freezes and damage by occupants. Basic checklists and procedural techniques for inspection are included in this manual. Other forms or checklists are available within each military branch and are included in numerous standards published by the National Fire Protection Association (NFPA).

1.6.2 Maintenance. Maintenance is the day-to-day, periodic, or scheduled work required to preserve or restore a facility to a condition so it can be effectively used for its designed purpose. It includes work to prevent damage or the deterioration of a facility that otherwise would be more costly to restore. Prompt maintenance done in an economical and workable manner is essential for personnel safety and to protect the facility from extensive fire damage. Therefore, detailed procedures, performed on schedule, should be provided in the Maintenance Program.

1.6.3 Repair. Repair is the restoration of a system to a condition that allows it to be used for its designed purpose. The repair may require overhaul, reprocessing, or replacing parts or materials that have deteriorated because of use or age and have not been corrected through maintenance. Repair can be part of a modernization program. The overall economy of the system and facility served and the requirements for a safe and operable system should be studied before recommending major repairs. Factors to evaluate include, but are not limited, to the following:

- Replacement cost of the system in relation to the expected life span of the system and the facility and to the cost of repairs
- Prompt detection of deficiencies or damage
- Operation and maintenance costs of the old versus a new system
- Possible obsolescence of the system and the present adequacy of the facility
- Present and future availability of maintenance funds
- Operational economics and safety hazards of downtime involved in major repair or replacement of facilities.

1.7 SAFETY. Safety precautions and safe maintenance practices are covered in the following documents:

- Army - EM 385-1-1
- Navy - NAVFACINST 5100.11F
- Air Force - AFOSH Standards
- OSHA regulations, sections 1910 and 1926.

The procedures addressed in this manual are in compliance with the noted OSHA regulations applicable in 1986.

1.8 TERMINOLOGY. Definitions of terms related to the operation, testing and maintenance of fire protection systems are in the glossary of this manual.

1.9 IMPORTANCE OF MAINTENANCE. According to the NFPA, approximately 6,185 civilians died in 1985 as a result of fires in the United States. In addition, more than 28,425 nonfatal civilian fire injuries occurred in 1984. The NFPA further estimates that direct property loss from fires in 1985 exceeded seven billion dollars.

While statistics for DOD facilities are not readily available, the NFPA statistics are evidence of the extent of the national fire loss. However, statistics such as these cannot reflect the effects of interfering with the continuity of DOD functions.

Fire protection systems are installed in structures to provide protection of life and property, and to assure the continuity of important missions. In order to operate effectively, fire protection systems are designed for the specific building and associated hazard using appropriate DOD standards. It is apparent, therefore, that the testing and maintenance of these systems are necessary to ensure operability.

For example, NFPA statistics indicate that automatic sprinklers are 96.2 percent effective in controlling fires, based upon data accumulated in the period of 1925-1969 (Table 1-1). An examination of the 3.8 percent "failures" shows that more than one half of these failures can be attributed to inadequate maintenance, including closed supply valves, empty gravity tanks and failure of fire pumps to start (Table 1-2).

Accurate statistics are not available as of this date, but it is estimated that the rate of satisfactory performance for other fire protection systems may be as low as 27 percent. Lower rates of acceptable performance are generally attributed to more complicated extinguishing systems, such as gaseous and chemical systems, which have more components susceptible to failure and which require increased maintenance.

TABLE 1-1
AUTOMATIC SPRINKLER PERFORMANCE SUMMARY, 1925-1969

	PERFORMANCE SUMMARY				CLASSIFICATION OF UNSATISFACTORY PERFORMANCE																
	Total No. of Fires	Total Unsatis- factory	Total Satis- factory	Total Satis- factory Per Cent	Off duty	tion	uate Supplies	tion	ive Dry- doe	Building action	ction tribution	t of ancy	re	uate nance	ated	aneous known					
Occupancies																					
Residential	1,073	48	1,025	95.5																	
Assembly	1,551	52	1,499	66.6																	
Educational	241	20	221	91.7																	
Institutional	305	12	293	96.1																	
Office	494	13	481	97.4																	
Mercantile	6,237	176	6,061	97.2																	
Industrial,																					
Beverages, essential oils	543	64	479	88.2	17	4	9	...	...	1	2	1	18	3	3	5	1		
Chemicals	4,147	198	3,649	95.2	33	11	19	...	3	3	1	13	95	2	12	1	5				
Fiber products	539	25	514	95.3	6	...	4	1	...	2	...	5	4	...	2	1	...				
Food products	2,484	133	2,351	94.6	43	11	8	1	2	1	7	9	29	4	12	1	5				
Glass Products	519	23	496	95.6	8	...	3	1	...	...	2	1	5	...	3	...	...		
Leather, leather products	2,884	114	2,750	96.0	43	8	7	3	2	4	9	7	9	4	9	6	3				
Metal, metal products	9,807	305	9,502	96.9	91	36	22	3	6	6	15	35	43	6	29	7	6				
Mineral products	394	19	375	95.2	10	4	2	...	...	...	1	...	...	...	1	1	...
Paper, paper products	7,147	234	6,913	66.7	75	18	34	3	2	2	16	32	21	2	23	4	4				
Rubber, rubber products	1,489	61	1,428	95.9	21	4	3	...	1	1	1	10	14	1	5	...	...		
Textiles - manufacturing	16,119	291	15,828	98.2	109	15	32	3	5	3	11	27	18	1	50	9	8				
Textiles-processing	6,527	127	6,400	98.1	52	6	11	...	5	1	8	13	15	2	7	1	6				
Wood products	5,353	492	4,861	90.8	137	57	84	9	16	14	27	19	77	8	24	12	8				
Miscellaneous industries	9,013	265	8,748	97.1	146	15	14	8	3	...	12	11	18	3	27	8	...				
Total (Industrial)	66,945	2,351	64,594	96.5	791	187	252	32	45	38	112	183	366	36	207	56	46				
Storage Occupancies	4,160	375	3,785	91.0	122	24	48	5	6	9	10	57	38	11	40	3	7				
Other Occupancies	419	87	332	79.2	67	...	...	2	...	...	2	1	5	3	3	1	3
TOTAL (ALL OCCUPANIES)	81,425	3,134	78,291	66.2	1,110	254	311	44	56	53	187	256	424	52	262	65	60				

TABLE 1-2
DETAILED ANALYSIS OF UNSATISFACTORY AUTOMATIC SPRINKLER PERFORMANCE

	<i>Residential</i>	<i>Assembly</i>	<i>Educational</i>	<i>Institutional</i>	<i>Office</i>	<i>Mercantile</i>	<i>Industrial</i>	<i>Storage</i>	<i>Miscellaneous Occupancies</i>	<i>Total</i>
Water to sprinklers shut off										
Valve defective or leaky	..	..	..	..	..	..	3	..	1	4
Unsupervised valve closed for undetermined reason	2	9	..	1	..	16	176	36	7	247
Premature shutoff	2	4	1	..	..	13	193	23	7	243
Alterations or repairs to system	3	5	..	..	1	14	179	28	10	240
To prevent framing	1	1	1	2	1	24	127	18	26	201
Cold-weather valve closed out off season	..	1	..	..	..	7	24	4	..	36
To avert arson	1	..	2	..	..	5	33	6	2	49
Fear of water damage	..	..	..	..	2	..	18	1	..	21
Miscellaneous other reasons	4	3	..	..	..	4	38	6	14	69
Partial protection										
Originated in unsprinklered area	7	10	8	3	2	10	180	23	1	244
Spread to unsprinklered area	2	..	..	..	..	1	7	..	..	10
Inadequate water supply										
Insufficient water or low water pressure from public supply	2	2	..	..	..	2	114	19	..	139
Insufficient water or low water pressure from private supply	1	..	1	1	..	..	26	6	..	35
Insufficient water for both sprinklers and hose streams	1	1	..	..	1	..	53	13	..	69
Gravity tank empty	1	..	..	..	..	1	22	3	..	27
Pump failure or pump not stinted	..	..	..	1	..	..	14	..	..	15
Mains broken	..	..	..	..	..	1	11	1	..	13
Miscellaneous reasons	..	..	..	..	..	..	12	1	..	13
System frozen										
Pipes or valves frozen	1	..	..	..	..	4	32	5	2	44
Slow operation										
Excessive heads on dry-pipe valve	..	..	..	..	..	..	19	1	..	20
High-temperature sprinklers	..	1	..	..	..	..	9	..	..	10
Failure of quick-opening device	..	..	..	..	..	..	4	..	..	4
Heat-actuating devices inadequate or inoperative	..	..	..	..	..	..	3	..	..	3
Miscellaneous reasons	..	..	..	..	..	4	10	5	..	19
Defective dry-pipe valve										
Defective or improperly adjusted dry-pipe valve	..	..	..	..	1	5	38	9	..	53
Faulty building construction										
Concealed horizontal or vertical spaces lacking protection	11	9	4	1	2	34	94	5	1	161
Floor or roof collapse	..	..	1	..	..	1	12	6	1	21
Miscellaneous deficiencies	..	..	..	..	..	..	5	..	..	5
Obstruction to distribution										
Fires under benches, etc.	..	..	..	..	..	2	98	8	..	108
High piling of stock	..	..	..	..	..	3	60	41	..	104
Partitions erected	1	..	..	..	..	5	12	4	1	23
Miscellaneous reasons	2	1	..	..	..	1	13	4	..	21
Hazard of occupancy										
Hazard too severe for sprinkler equipment as installed	..	..	..	..	..	6	182	23	3	214
Explosion damaged system	1	..	..	..	1	6	161	13	2	164
Water overflowed containers of flammable liquids	..	..	..	1	..	..	15	..	..	16
Miscellaneous reasons	..	..	..	..	..	..	8	2	..	10
Exposure fire										
Exposure fire overpowered sprinkler system in exposed building	..	1	..	..	..	1	36	12	2	52
Inadequate maintenance										
Plugged sprinklers	..	2	..	..	..	1	39	8	..	50
Sprinklers dirty, corroded, or coated	..	..	..	..	..	1	41	4	2	48
Obstructed piping	2	2	1	..	..	2	117	25	1	150
Defective check	..	..	..	..	..	..	2	2	..	4
Miscellaneous reasons	..	..	..	..	1	..	9	..	..	10
Antiquated system										
Pipe sizes, sprinkler spacing substandard or old-standard	2	..	1	..	..	1	51	3	..	58
Valves substandard or old-standard	..	..	..	..	..	..	1	..	..	1
Sprinklers substandard or old-standard	..	..	..	..	1	..	3	..	1	5
Miscellaneous deficiencies due to age	..	..	..	..	..	..	1	..	..	1
Miscellaneous and unknown										
Causes of unsatisfactory sprinkler performance unknown or cannot be otherwise classified	1	..	..	2	..	1	46	7	3	60
TOTAL	48	52	20	12	13	176	2,351	375	87	3,134

CHAPTER 1. SELF-STUDY QUESTIONS

Instructions: Select the correct answer(s) for each of the following questions.

Q1-1 The objective of the maintenance program for fire protection systems is:

- a. Prompt detection of deficiencies or damage.
- b. Replacement or repair of damaged equipment in an economical manner.
- c. Replacement or repair of damaged equipment as soon as possible.
- d. Preservation of life, property and continuity of operations.
- e. All of the above.

Q1-2 This manual includes the maintenance of fire suppression equipment of fire department vehicles:

- a. True
- b. False

Q1-3 Technical support for the maintenance of fire protection systems is available from each branch of service:

- a. True
- b. False

Q1-4 The instructions in this manual supersede the instructions of the manufacturer of a particular device or system:

- a. True
- b. False

Q1-5 When extending or upgrading an existing fire protection system, redesign criteria for the new equipment may be found in this manual.

- a. True
- b. False

Q1-6 Statistics show that more than one-half of sprinkler systems failures can be attributed to maintenance related deficiencies.

- a. True
- b. False

Q1-7 Maintenance is the:

- a. Restoration of a facility to a condition that allows it to be used for its designed purpose.
- b. Regularly scheduled visual and mechanical checking of the conditions of a facility.
- c. Periodic work required to preserve or restore a facility that allows it to be used for its designed purpose.
- d. Evaluation of various costs associated with the operation and repair of a facility.

Q1-8 This manual contains definitions of various terms related to fire protection systems and their maintenance.

- a. True
- b. False

CHAPTER 2. FIRE ALARM SYSTEMS

2.1 GENERAL. The purpose of a fire alarm system is to protect life, property and the continuity of operations by giving early warning of a fire so that occupants may evacuate the building and the fire department may be notified.

Fire alarm systems generally fall into two broad classifications: (1) building or local fire alarm systems and (2) base fire alarm systems. Each of these system types may also be coded or noncoded, using either line voltage or low voltage electric power. The following sections explain the methods of classifying the various types of alarm systems and describe the general features or functions of each type.

2.2 BUILDING ALARM SYSTEMS. A building or local fire alarm system provides audible and/or visual alarm signals as the result of manual operation of a fire alarm box or automatic operation of protective equipment such as sprinkler systems and heat or smoke detectors.

Additional signal and emergency functions can be added to building alarm systems, such as fire door closing and fan shutdown. However, it should be noted that these add-on functions are not the primary purpose of the alarm system.

2.2.1 Building Alarm System Types. Building alarm systems may be local, or local with base alarm system connection. They may be coded or noncoded and operate either on line voltage or low voltage electric power. Their characteristics are described in the following paragraphs.

2.2.1.1 Noncoded Alarm Systems. A noncoded alarm system has one or more alarm indicating appliances to alert the building occupants of a fire but does not tell the location or the type of device which has been activated (manual alarm or automatic protection equipment). The audible and/or visual alarm appliances operate continuously until they are turned off, a predetermined time has passed or the system is restored to normal status. The location or type of device originating the alarm condition can be determined by one of the following methods:

- No Annunciation. Annunciation may be eliminated in small buildings where a fire can be located easily. The building alarm signal indicates which building the signal originates from; a specific location of the fire is determined by search.
- Annunciation at Control Unit. The annunciator helps locate the fire or the originating device. Annunciation at the control unit is frequently used in larger building systems that have several alarm subsections, especially if there are several types of alarm devices or if the building has areas not easily seen from a central location.

An annunciator consists of lights or other indicators on a fire alarm control panel to show the point of alarm origin. Each light represents a protected area or zone of the fire alarm system (Figure 2-1). A graphic annunciator has lights on an area map to show location more precisely.

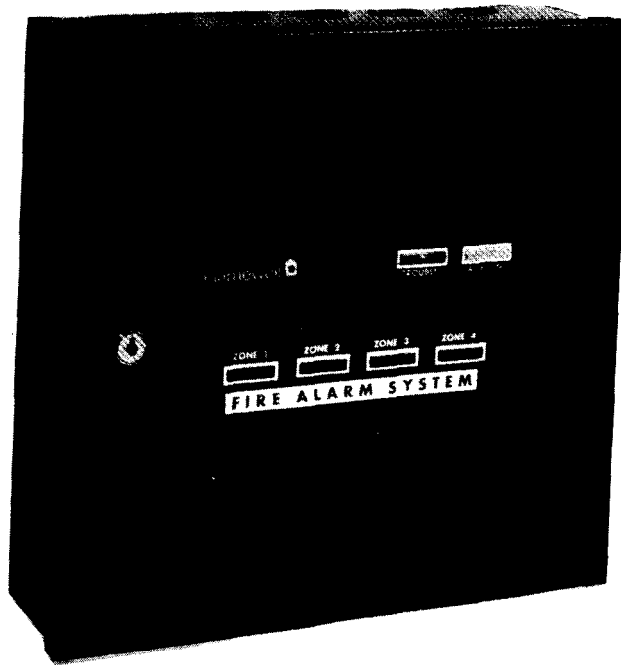


FIGURE 2-1
CONTROL UNIT WITH ANNUNCIATION

- 1 Annunciation at a Remote Location. If the control panel cannot be located where it will be constantly attended, a remote annunciator can be placed in a reception area, telephone operator area, guard shack, or other area where it can be observed. An annunciator may be located on the building exterior so it is easily accessible to the fire department.

Each zone of annunciation is clearly labeled on the remote annunciator to identify the protected zones (Figure 2-2).

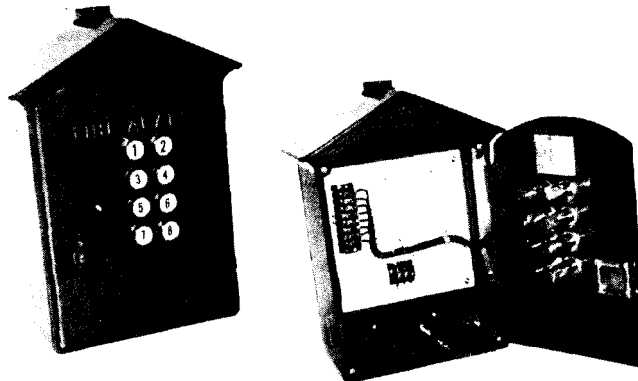


FIGURE 2-2
REMOTE ANNUNCIATOR (WEATHERPROOF)

- Multiple Annunciation. Some large fire alarm systems may require annunciators in more than one location, such as the telephone switchboard, maintenance office, security office, or the main entrance. Generally, fire alarm control panels with the annunciation feature can be adapted to annunciate at multiple remote locations. Each annunciator may show identical information or a preselected different set of zones might appear at each annunciator.

2.2.1.2 Coded Alarm Systems. A coded alarm system has audible and/or visual alarm signals with distinctive pulsing or coding to alert occupants to a fire condition and to the location or type of device which originated the alarm. Coding the audible appliances may also be used to help distinguish the fire alarm signal from other audible signals which may be in use or to encourage a more orderly and disciplined evacuation of the building. A common characteristic of coded alarm systems, most especially of selective coded and multiplex coded systems, is that the coded alarm identification provided by the audible alarm signals is not repeated continuously. Normally, after four complete repetitions of the coded signal, the coding process ends. Examples of coded alarm signals are given in the following sections.

- Master Coded. A master coded local alarm system prevents confusion between fire alarm audible signals and other audible signals in the building. When the system is activated, a coding mechanism or electronic circuitry at the fire alarm control panel causes all the building indicating devices to pulsate in a distinctive repetitive pattern, identifying the signal as a fire alarm signal but does not indicate where the fire is.
- March-Time Coded. A march-time coded signal is one particular master coded signal. When the repetitive pattern of the fire alarm audible signals is arranged to sound in a pulsating, march-time cadence (approximately 120 pulses per minute), the signals are march-time coded. March-time coded signals are sometimes used for buildings with heavy population densities, such as schools, to encourage orderly, rapid evacuation of the building. Coding of the signals is done by a coding mechanism or electronic circuitry in the fire alarm control panel.
- Selective Coded. In a selective coded local alarm system, each alarm initiating device has a coder or each device or zone is connected to a separate coder at the fire alarm control panel. The coder causes the alarm signals to pulsate in a distinctive repetitive pattern which identifies the location and/or type of alarm initiating device.
- Multiplex Coded. Multiplex coding uses wire or radio for signal transmission and allows several signals to be transmitted and received simultaneously and/or sequentially, over the same communication channel. The transmission method includes means to positively identify each signal. Multiplex normally implies the use of computer based equipment at the control unit.

A large building system may use multiplexing to get a maximum number of identified points (zones) with minimum wiring. Alarm initiating devices normally are wired to zone terminals in a local multiplex interface unit, commonly called a data gathering panel. A multiplex control unit constantly scans a number of interface units and obtains the coded zone status information from these units.

- Coded Signal Recorders and Displays. Coded signal recorders and displays provide a means to identify and respond to a coded alarm if the signal was not noticed or has stopped operating. The signal recording devices provide a permanent record of all status changes of all devices in the system. A display presents the same information temporarily, usually by means of lighted numbers and/or letters. Many coded systems provide location information in the coded signal as well as status information. The coded signal can identify whether the detection device originating the signal is telling the system that it is reporting an alarm, a trouble or a return to normal status.

Paper Tape Recorder. The paper tape recorder, or register (Figure 2-3) has historically been used to record the pulses produced by a coded alarm transmitter. The recorder marks a status change of a coded alarm by punching holes or printing ink dots on the paper tape. The number of holes or dots indicates the code number--and therefore the location--of the alarm. The number of times the pattern repeats indicates the status of the detection device (e.g. four repeats is alarm; one repeat is trouble).

If one circuit is monitored the tape is usually 1/2 inch wide; if more than one circuit is monitored, the tape is usually 3 or more inches wide. More details on this equipment are in the section on Signal Recorders, later in this chapter.

Alpha-Numeric Paper Tape Recorder (Printer). The Alpha-Numeric paper tape recorder is normally used only with the newer coded or multiplex alarm systems, "out they are available for retrofit on older types of coded alarm systems .

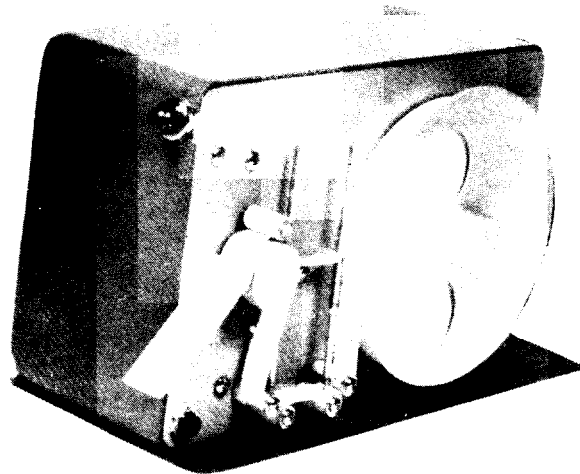


FIGURE 2-3
PAPER TAPE RECORDER

The Alpha-Numeric recorder (Figure 2-4) is frequently used with some other temporary means of alarm display, such as a solid state display or cathode ray tube (CRT). The recorders provide a hard-copy record of alarms, normally in an abbreviated alpha-numeric form, but sometimes in full text alpha-numeric. The number identifies the location of the device causing the alarm, and the message indicates the alarm status.

A typical display and/or printout would be "2.04.12 WTRFLOW RST" indicating that waterflow alarm number 2.04.12 has restored to a normal condition (after a waterflow alarm). The location is determined from a reference list arranged in numerical order or from a cathode ray tube or projected photographic slide display. Where a full text alpha-numeric format is used, all pertinent information is provided and the numerical reference list or display is not required. The paper tape used for the printer is usually 3 inches or more wide.

2.2.1.3 Operating Voltage. Fire alarm systems are in two general categories, determined by the voltage at which the systems operate--line voltage and low voltage. Regardless of the operating voltage, a system may also be noncoded or coded.

Generally, line voltage systems are used where only manual fire alarm and evacuation signaling service are provided. Low voltage alarm systems, especially those provided with battery standby power, are most often found where some form of automatic fire detection or automatic fire extinguishing is connected to the alarm system. However, recent conversion by most alarm system manufacturers to solid state electronic design, which is essentially a low voltage direct current technology, means that most recent installations are of the low voltage type.

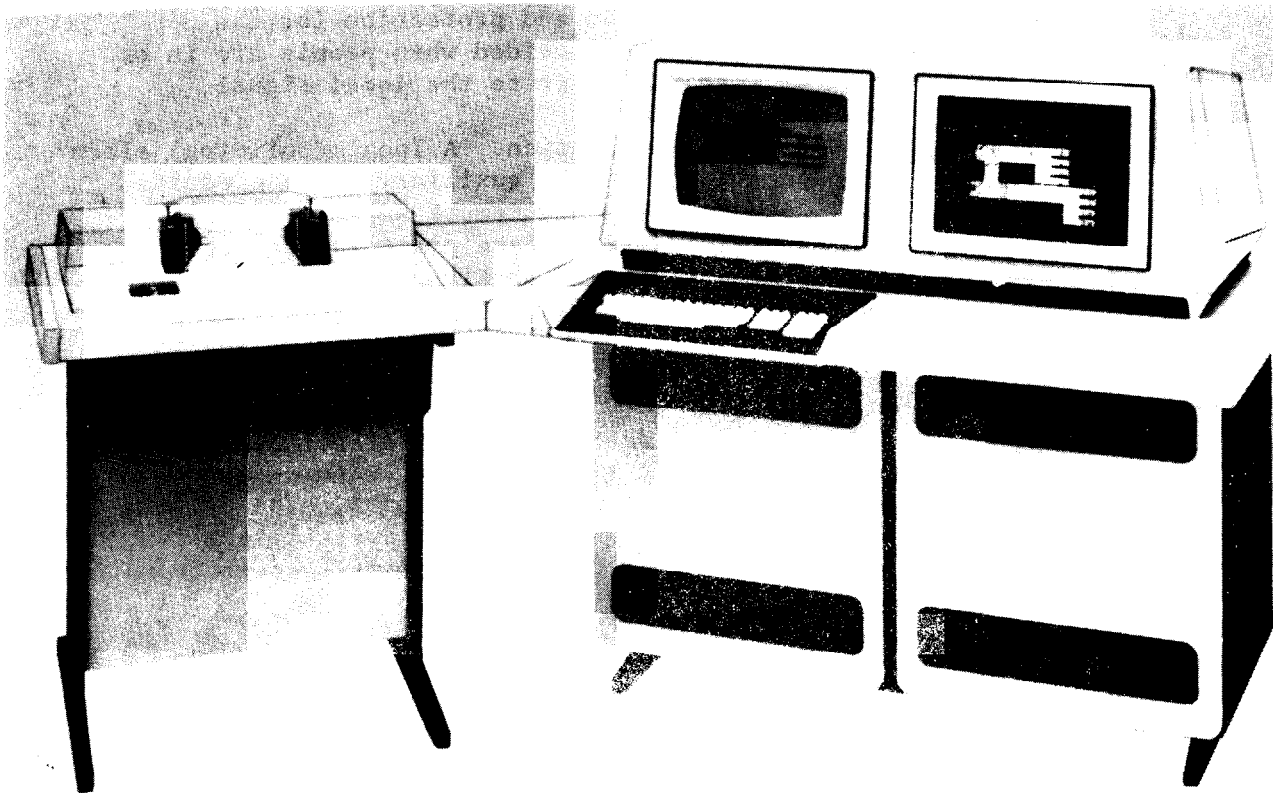


FIGURE 2-4
ALARM CONSOLE WITH ALPHA-NUMERIC RECORDER AND CRT DISPLAY

- **Line Voltage Systems.** Many older local alarm systems are powered by AC power only with no provision for standby battery power. In these cases, two separate AC circuits (usually 120/240 VAC) are used; one to power the fire alarm system operating circuits and the other to power the trouble signaling circuits of the system. In case of alarm system power failure or other malfunction, an audible and/or visual trouble signal indicates the need to correct the alarm system failure.
- **Low Voltage Systems,** Historically, low voltage direct current fire alarm systems have been used with automatic detection. Today, most alarm systems are low voltage systems with a capability for standby battery and battery recharging. Usually 24 hours of operating capacity on battery power is provided.

2.2.1.4 **Local Alarm/Local Alarm System With Base Alarm Connection.** So far, the types of local fire alarm systems which may be encountered in various buildings or facilities on a military installation have been discussed. Some systems are local systems only but in the majority of military installations they are local systems with base alarm connection, the distinction being as follows:

- **Local System.** A local fire alarm system has audible and/or visual alarm signals that operate only in the protected building and does not transmit signals to a remote, continuously attended location, such as a fire station. These systems are frequently found at military installations. Such signals protect the lives of the occupants, but property protection and protection for the continuity of operations is only provided when people are in or around the building to hear and react to the local signal.
- **Local System with Base Alarm Connection.** A local (building) alarm system can be equipped to activate an auxiliary alarm circuit. This circuit can be used to operate a remote signal transmitter connected to the base alarm system. Base alarm system signal transmitters can also be connected directly to initiating devices, such as waterflow alarm devices, which have no direct connection to a local alarm system. In either case, an identifying code is transmitted to the base alarm system receiver, which is normally located at the fire station.

2.2.2 **Building Alarm System Components.** Figure 2-5 shows how the basic components of a local fire alarm system are interconnected. The devices in the diagram are grouped for convenience in labeling. Physical location and zoning of devices vary for different applications and many systems do not have all the devices shown.

2.2.2.1 **Control Unit.** The fire alarm control unit provides termination points for all initiating circuits, indicating circuits, remote annunciators, and other auxiliary devices. The control unit accepts low current signals from the alarm initiating circuits and, through relays or other circuitry, provides the larger current required to operate the alarm indicating devices and/or auxiliary devices. The condition of the alarm initiating and indicating circuit wiring is continuously monitored by the control unit. Trouble indication is provided in the event of an abnormal condition in the system, such as an AC power failure or a wiring failure.

The control unit is usually housed in a sheet metal cabinet (Figure 2-1). In larger systems it may be in a floor mounted console with a desk work area (Figure 2-4). Accessory cabinets for terminal boards, remote transmitters, and power supplies might be in a nearby, separate room from the main control unit. The control unit usually provides annunciation of signals (telling where a signal originates).

Traditionally, the control unit monitors the status and "knows" the location of actuated devices using electronic circuitry. In recent years, computers have been used to eliminate the need for custom-designed electronic circuitry. Computers are used in hard-wired and multiplex systems.

State-of-the-art systems utilizing computers as part of the control unit on hard-wired systems address the needs of a specific building by the software (computer programs). Referred to as "intelligent" or "addressible" fire alarm system, installers can, via the software, enable the computer to identify actuated initiating devices by location, monitor the sensitivity of initiating devices (and indicate when the sensitivity has changed beyond acceptable limits), initiate auxiliary features, etc.

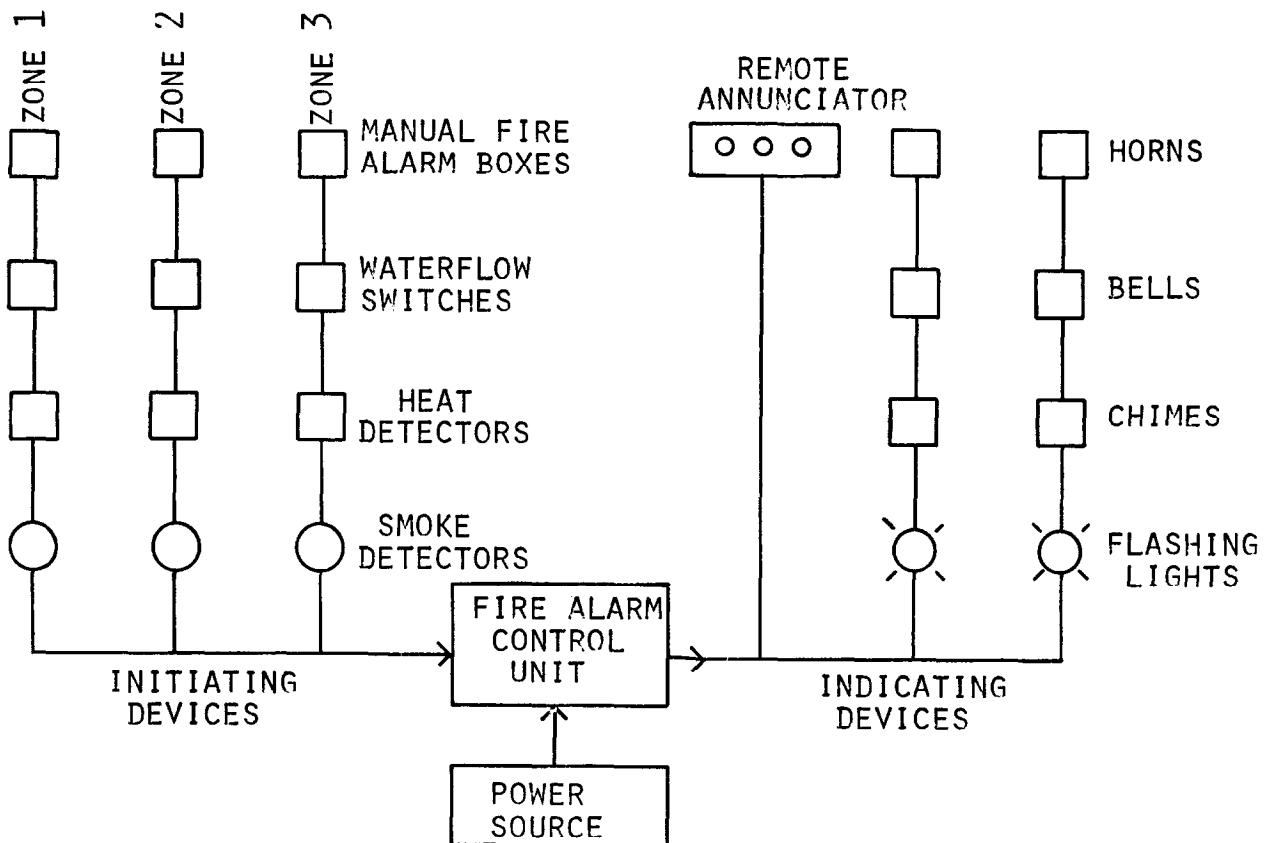


FIGURE 2-5
LOCAL FIRE ALARM SYSTEM DIAGRAM

Because all circuits terminate at the control unit, it is a convenient test location. Test switches (if provided) are usually inside the locked door of the control unit. Only, if the switches are key operated will they be on the control unit exterior.

Test switches may include audible alarm and trouble silencing switches, an alarm test switch, and a drill switch. If an initiating circuit, a device, or a control unit malfunctions and the audible alarm sounds, the alarm silence switch at the control unit can be moved to the silence position.

In addition, the normal sequence of actions required to restore the alarm system to its normal operating condition is shown in Table 2-1.

TABLE 2-1
ACTIONS REQUIRED TO RESTORE ALARM SYSTEM
TO NORMAL OPERATING CONDITION

<u>Action</u>	<u>Result</u>
1. Operate alarm silence switch to the silence position.	Audible alarm signals stop. Audible trouble signals start.
2. Operate trouble silence switch to the silence, position.	Audible trouble signals stop. Visual trouble indicator illuminates .
3. Correct or repair malfunction.	No change in indicators.
4. Restore alarm silence switch to the normal position.	Audible trouble signals start.
5. Restore trouble silence switch to the normal position.	Audible trouble signals stop. Visual trouble indicator light extinguishes.

†
If there is a test switch in the control unit, it simulates an alarm condition. Operating the test switch causes audible signals to sound, causes fan shutdown, fire door closing, and transmission of an alarm signal to a remote receiver, if these features are provided. Before operating a test switch, be sure preparations for a test are made, including notifying proper authorities to avoid undesired fire department response and inconvenience or possible panic to the building occupants.

A drill switch in the control unit sounds the alarm audible signal without activating any of the alarm system auxiliary features. The drill switch is intended for use in fire drills.

2.2.2.2 Initiating Devices and Circuits. An alarm device initiates a fire alarm signal either as a result of manual operation, such as a manual fire alarm station, or automatically, in the case of heat, smoke or waterflow detectors. Initiating devices, with rare exceptions, have normally open contacts which close on an alarm condition. Normally closed devices are intended only for applications such as fan shutdown and fire door closing or for use with municipal circuits (see Section 2.3.1).

The initiating devices may be coded or noncoded. In coded fire alarm systems, the most common initiating devices are manually operated fire alarm boxes and waterflow transmitters. The coding device is usually driven by a spring-wound escapement mechanism. Manual fire alarm boxes are wound each time the actuating handle is operated. Releasing the handle allows the

mechanism to transmit the code. Waterflow transmitters are manually wound with a key and are activated by a mechanical linkage assembly to transmit the code when there is waterflow in the sprinkler system. One or more noncoded manual fire alarm boxes or waterflow switches can be connected to electrically activate one electric-motor driven coding device.

A coded initiating device connected to a building fire alarm system produces coded operation of the building audible and/or visual signals. If no measures are taken to prevent a clash of signals when two or more coded initiating devices are operated at the same time, the coding devices are "interfering ." To avoid such a clash, the following features may be provided:

- Shunt Noninterfering. Figure 2-6 illustrates the shunt noninterfering feature. Each coded initiating device on the initiating circuit has a set of normally closed coding contacts wired in series with all other coding contacts in the circuit. In addition, each initiating device has a set of normally open, cam-operated contacts which close and remain closed while the coding contacts are operating. These cam-operated contacts perform the noninterference function by shunting all coding contacts of initiating devices connected electrically beyond the coding contact which is operating. The last set of cam-operated contacts at the end of the initiating circuit performs no function and is not usually connected.
- Series Noninterfering. Figure 2-7 illustrates the series noninterfering feature. Each coded initiating device has a set of normally open coding contacts and the coding contacts for all the devices on the circuit are connected in shunt (parallel). At the end of the initiating circuit is an end-of-line resistor. In addition, each initiating device has a set of normally closed, cam-operated contacts which open and remain open while the coding contacts are operating. These cam-operated contacts are connected so that, when open, they disconnect all coding contacts of initiating devices electrically beyond the coding contact which is operating. The last set of cam-operated contacts at the end of the initiating circuit performs no function and would usually not be connected.

2.2.2.3 Indicating Devices. The purpose of an indicating device is to alert people to the presence of an alarm or trouble condition. Alarm indicating devices in a building alarm system can be annunciators or audible signals or a combination of both.

- ANNUNCIATORS. Annunciators give a visual indication of the "zone" or general area where an alarm originates. In some cases, the annunciator can be arranged to identify the individual initiating device, such as a sprinkler waterflow alarm. In other cases, such as heat detectors, many initiating devices may activate the same indicator on the annunciator.

The annunciator indicator can be operated directly by auxiliary contacts in the initiating device or from a connection to the fire alarm control unit. A trouble or maintenance condition in the system wiring is also frequently annunciated by zone. Usually, a yellow or amber light indicates trouble and a red light indicates an alarm signal. ,

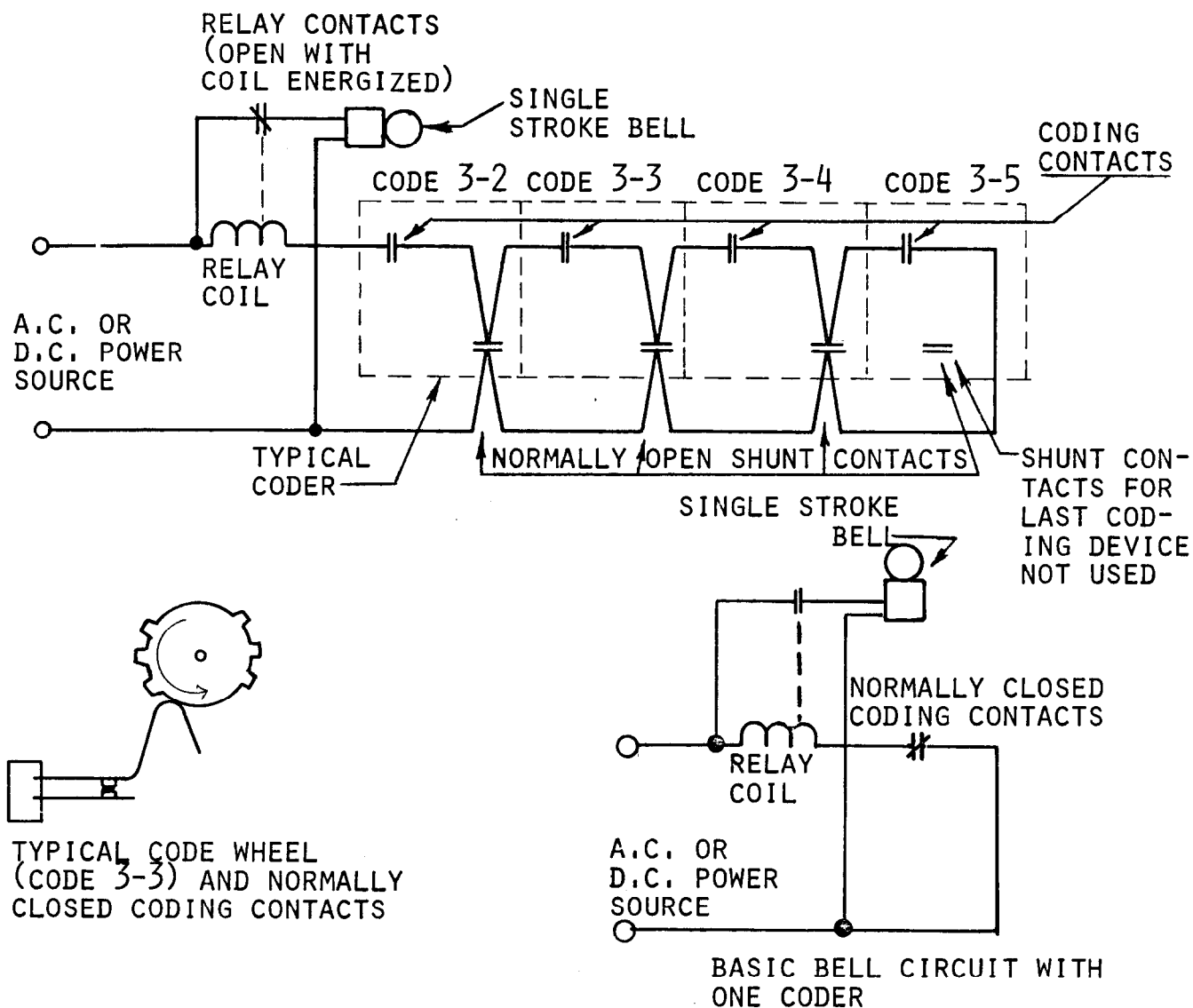
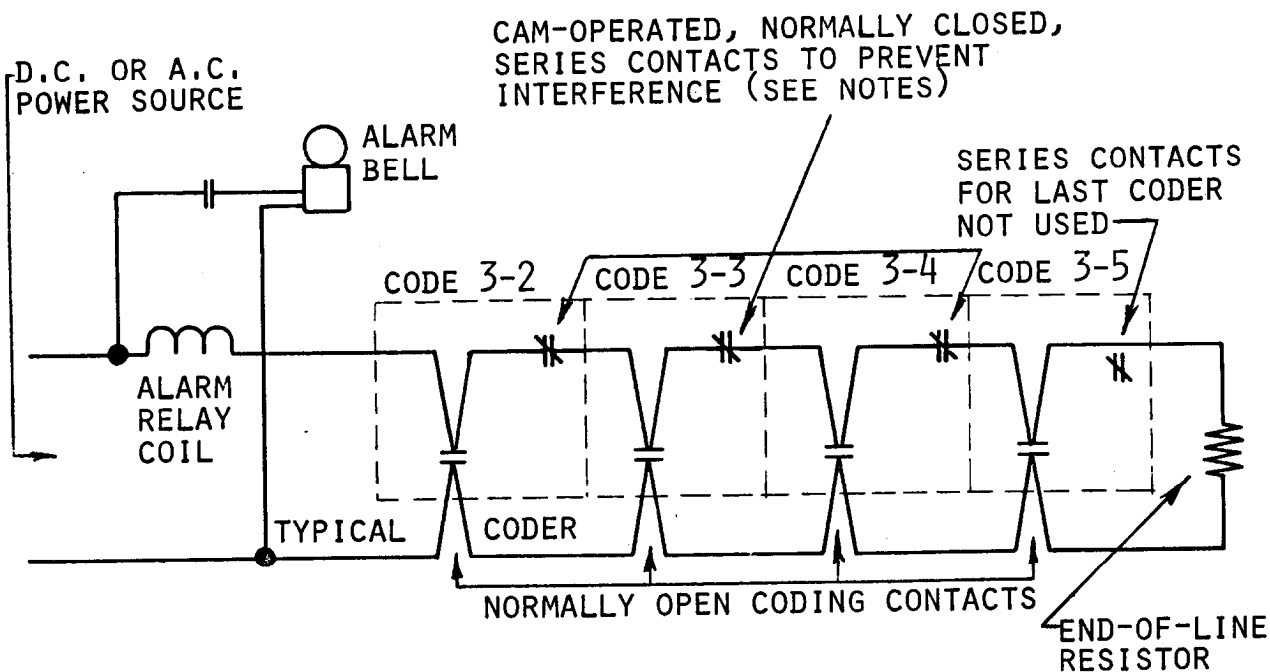


FIGURE 2-6
SHUNT NONINTERFERING CODED ALARM SIGNALING CIRCUIT^T



NOTE: A SET OF CAM-OPERATED, SERIES CONTACTS OPENS WHEN ITS CODER STARTS OPERATING AND CLOSSES WHEN SIGNAL IS COMPLETE. IF CODE 3-3 IS TRANSMITTED, ITS SERIES CONTACTS OPEN, DISCONNECTING CODERS 3-4 AND 3-5 FROM THE CIRCUIT. IF CODER 3-2 THEN STARTS, CODE 3-2 TAKES PRIORITY, DISCONTINUING CODE 3-3. CODER 3-3 COMPLETES ITS CYCLE WITHOUT AFFECTING THE SIGNAL. FOR TWO CODERS OPERATING SIMULTANEOUSLY, THE CODER CLOSER TO THE POWER SOURCE TAKES PRIORITY.

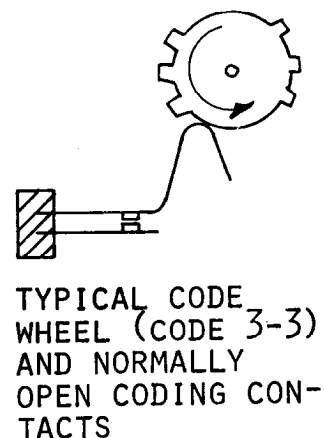


FIGURE 2-7
SERIES NONINTERFERING CODED ALARM SIGNALING CIRCUIT

An annunciator may be incorporated into the fire alarm control unit, in which case it is generally actuated by connection to the control unit. It may also be located at a remote point, in which case it may be actuated either by the control unit or by auxiliary contacts in the initiating devices. Some installations may have a fire alarm control unit with an integral zone annunciator and a remote annunciator provided elsewhere. Frequently, the control unit standby battery is used to provide power for annunciator operation during power failures.

Annunciator visual indicators may be the drop type or the lamp type. Drop type annunciators (which are essentially obsolete) use electromagnetic devices to move a flag into or away from a window to indicate a change in zone condition. A lamp type annunciator uses pilot light assemblies to indicate an alarm or trouble condition (usually red for alarm, amber for trouble). The most common type of annunciator in use today is the lamp type. Figure 2-2 shows a frequently used incandescent lamp annunciator.

More recent annunciator designs use matrices or arrays of light-emitting-diodes (LEDs). The advantages of LEDs are low current, long life and small size, allowing annunciation of many zones in a small space.

- Audible Signal Appliances. Any device that sounds an audible signal is classified as an audible signal appliance. The audible signal appliances most frequently used in building alarm systems are bells and horns. In addition there are chimes, cow bells, buzzers, sirens, speakers, air horns and steam whistles. Audible signals can be used to indicate either a fire alarm or a system malfunction (trouble) condition. The audible signal appliances are connected to audible signal circuits for alarm or trouble indication (depending on their function) at the control unit. Figure 2-8 shows some of the commonly used audible signal appliances.

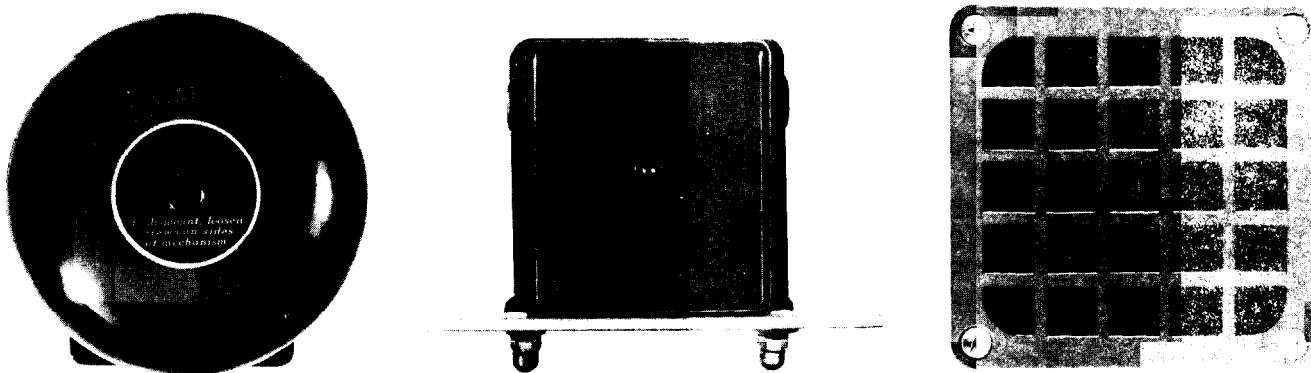


FIGURE 2-8
AUDIBLE SIGNAL APPLIANCES

Audible signal appliances have varying levels of sound output. Louder devices are for areas with high ambient sound levels or where the devices cannot be located near the area to be warned. Hospitals might use softer devices, such as chimes, to avoid frightening patients.

Coded building alarm systems normally use single-stroke versions of bells or chimes so the coded signal can be clearly produced. Vibratory bells, chimes, or horns are used for noncoded systems but can also be used in coded systems if the mechanism used can respond rapidly enough to provide an accurate rendition of the code being transmitted. If audible signals are used routinely, such as bells for announcing class periods in a school, the fire alarm audible appliances must have a distinct, easily identified sound. If the fire alarm signal is coded, the coding provides the distinctive sound, and it is feasible (though not normal) to use the same bells for both functions. In a noncoded fire alarm system, necessary distinction of the fire alarm signal is obtained by using a completely different type of audible signal appliance, such as a horn or siren.

Some fire alarm systems sound a presignal alarm, using only a few audible devices located where they can be heard by persons in authority and who are familiar with the building and its alarm system. When the alarm sounds, these persons can investigate the cause of the alarm and activate

the general alarm if necessary. Activation of the general alarm signal appliances in a presignal system is usually accomplished by the use of a key at the nearest manual fire alarm device or at the control unit. If the alarm is triggered by a nonfire cause, the alarm system can be reset without operating the general alarm signals. Some presignal systems are arranged to signal a general alarm automatically after a time delay of a few minutes if the alarm system has not been restored to normal. The general evacuation alarm signal appliances are usually separate and distinct from presignal appliances and are located so as to be heard and seen by all occupants of the building.

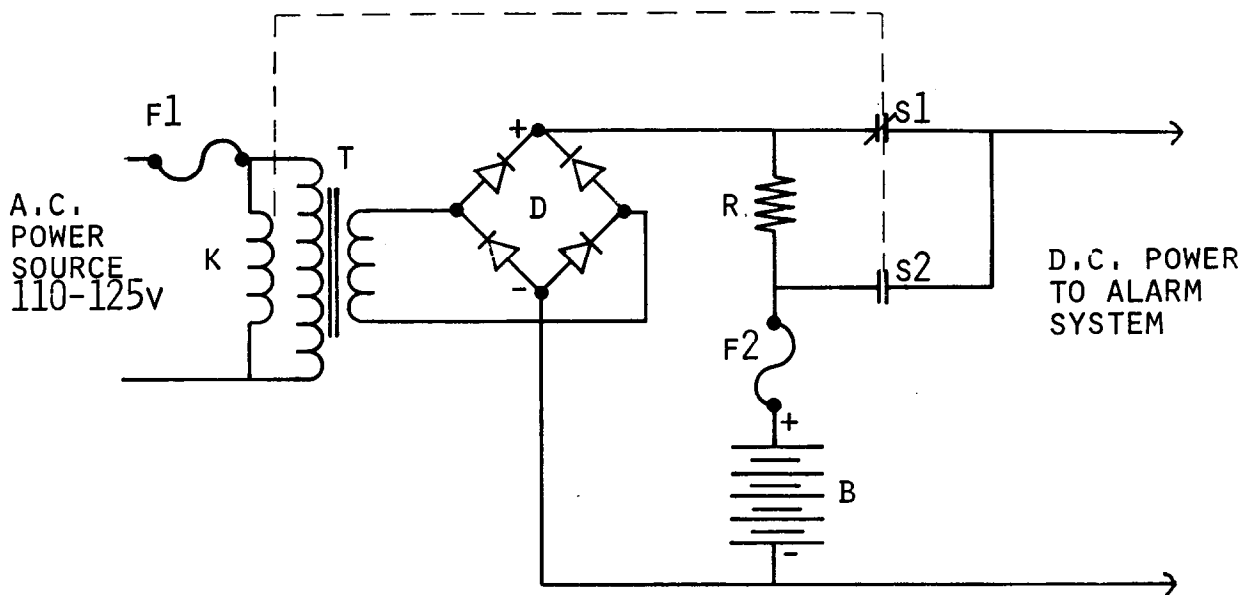
- Visual Signal Devices. Visual devices, such as lighted signs or fire alarm strobe lights, are used in areas where either a high ambient noise level exists or the building is occupied by hearing-impaired individuals. An area with a high ambient noise level is one in which single or double hearing protection is required.

2.2.2.4 Power Supplies.

- System Power Supply. Power supply refers to the circuitry and components used to convert AC line voltage to low voltage AC or DC for operating the alarm system and charging standby batteries. If an older system has a dry cell, nonrechargeable standby battery (no longer permitted by NFPA standards), the power supply usually includes switches for connecting the battery to the system when AC power fails. Figure 2-9 is a simplified diagram of a typical DC power supply for powering a low voltage DC alarm system and charging a rechargeable standby battery.

There are many variations of this basic power supply design which add such features as voltage regulation, current limiting and automatic high rate/low rate charging, controlled by the state of battery charge. "Deep cycling" may be required of NiCad batteries to completely recharge the battery. All designs normally provide current and voltage meters, pilot lamps, and switches for manual control of charging rate.

- Smoke Detector Power Supply. When smoke detectors are used in an alarm system, their internal electronic circuits are usually powered from the main fire alarm power supply. Some types of smoke detectors have a more strict power supply requirement than other parts of the fire alarm system, especially with regard to purity of the DC voltage level. The power supply for those smoke detectors must have output voltage regulation and filtering not otherwise required by the fire alarm system. In those cases, the basic power supply may be upgraded to power the smoke detectors as well as the control unit, or a separate smoke detector power supply may be used in addition to the basic supply. In either case, if the system has battery standby, it is usually common to both power supplies.



- F1 AND F2 - OVERCURRENT PROTECTIVE FUSES
 K - A.C. POWER SENSING RELAY COIL (CONTROLS CONTACTS S1 AND S2)
 T - VOLTAGE STEP-DOWN TRANSFORMER
 D - FULL WAVE RECTIFIER BRIDGE
 B - RECHARGEABLE STANDBY BATTERY
 R - CHARGE CURRENT LIMITING RESISTOR
 S 1 - CLOSED CONTACT WITH RELAY K ENERGIZED
 S 2 - OPEN CONTACT WITH RELAY K ENERGIZED

NOTES : TRANSFORMER; T, DROPS THE LINE VOLTAGE FROM 120 VOLTS A.C. TO A VOLTAGE IN THE RANGE 12 TO 48 VOLTS A.C. THE LOW A.C. VOLTAGE IS RECTIFIED BY DIODE BRIDGE, D, AND THE RESULTING PULSATING D.C. VOLTAGE POWERS THE ALARM SYSTEM THROUGH RELAY CONTACTS, S1, AND CHARGES BATTERY, B, THROUGH THE CURRENT LIMITING RESISTOR, R. WHEN NORMAL A.C. INPUT VOLTAGE IS PRESENT, ENERGIZING RELAY COIL, K, CONTACTS, S1, ARE CLOSED, IF A, C. POWER FAILS, DUE TO FUSE F1, BURNING OUT OR ANY OTHER REASON, S1 OPENS AND S2 CLOSSES, CONNECTING BATTERY B TO THE ALARM SYSTEM. FUSE, F2, PROTECTS AGAINST ALARM CIRCUIT DEFECTS WHICH WOULD CAUSE A BATTERY OVERLOAD DURING BATTERY POWERED OPERATION WHILE FUSE F1 PROTECTS AGAINST A DEFECT IN THE POWER SUPPLY OR THE ALARM SYSTEM DURING NORMAL A.C. OPERATION.

REMOVAL OF RESISTOR R ELIMINATES THE BATTERY CHARGING FEATURE AND ALLOWS THE USE OF A DRY CELL BATTERY WHICH SITS IDLE UNTIL A.C. POWER FAILS, AT WHICH TIME S1 OPENS AND S2 CLOSSES, CONNECTING THE BATTERY TO THE ALARM SYSTEM.

FIGURE 2-9
 TYPICAL DC POWER SUPPLY AND BATTERY CHARGER

2.2.2.5 Auxiliary Devices. A building alarm system control unit may have auxiliary contacts which operate auxiliary functions when an alarm occurs. For auxiliary devices, the power source can be either the main fire alarm power supply or line power, if battery standby power is not required for the auxiliary functions. A failure of auxiliary functions should not adversely affect the primary function of the alarm system, which is to warn the occupants of a threat of fire. For alarm system testing, one or more "bypass" switches are usually provided to allow system testing without activating the auxiliary circuits. If bypass switches are not provided, it may be necessary to make special arrangements prior to conducting any tests.

The following auxiliary functions can be controlled by the alarm system; activating base fire alarm system, fan shutdown/start-up, fire door closure, release of extinguishing agent and elevator recall.

- Activating the Base Fire Alarm System. The base alarm system can be activated by auxiliary alarm contacts connected to the initiating circuit of a transmitter which is compatible with the base alarm system. For more detail refer to the section on base alarm systems.
- Fan Shutdown/Start-up. The auxiliary contacts for fan shutdown or start-up are connected into the motor starter circuit for the HVAC (heating, ventilation, air conditioning) fans. A separate set of contacts is required for each fan that is to be affected.

It may be more convenient to use an alarm voltage output from the control unit to cause fan shutdown. A relay with multiple contacts (a multiple relay) for controlling multiple fans is located near the motor control center or the temperature control panel. The relay coil is energized by alarm voltage from the alarm control unit causing contacts to open in the individual fan control circuits, stopping all the fans. Figure 2-10 shows a typical circuit for fan shutdown or other auxiliary functions.

- Fire Door Closure. Door closure operation is usually controlled by an electric door holder working with a mechanical door closing mechanism. Electric door holders may be either normally energized or deenergized. The most common door holders are normally energized and use an electromagnet, typically mounted on the wall or floor as a door-stop. A swivel mounted armature is mounted on the door, positioned so it contacts the electromagnet when the door is fully opened. During normal conditions, the door is held by the electromagnet with a force of 20 to 25 pounds. When a fire alarm occurs, auxiliary contacts at the fire alarm control unit open, removing power from the electromagnet and releasing the door. Figure 2-11 shows one of the more common electromagnetic door holder devices. Variations of door closure devices combine the electric door holder mechanism and the mechanical door closer unit in a single package.

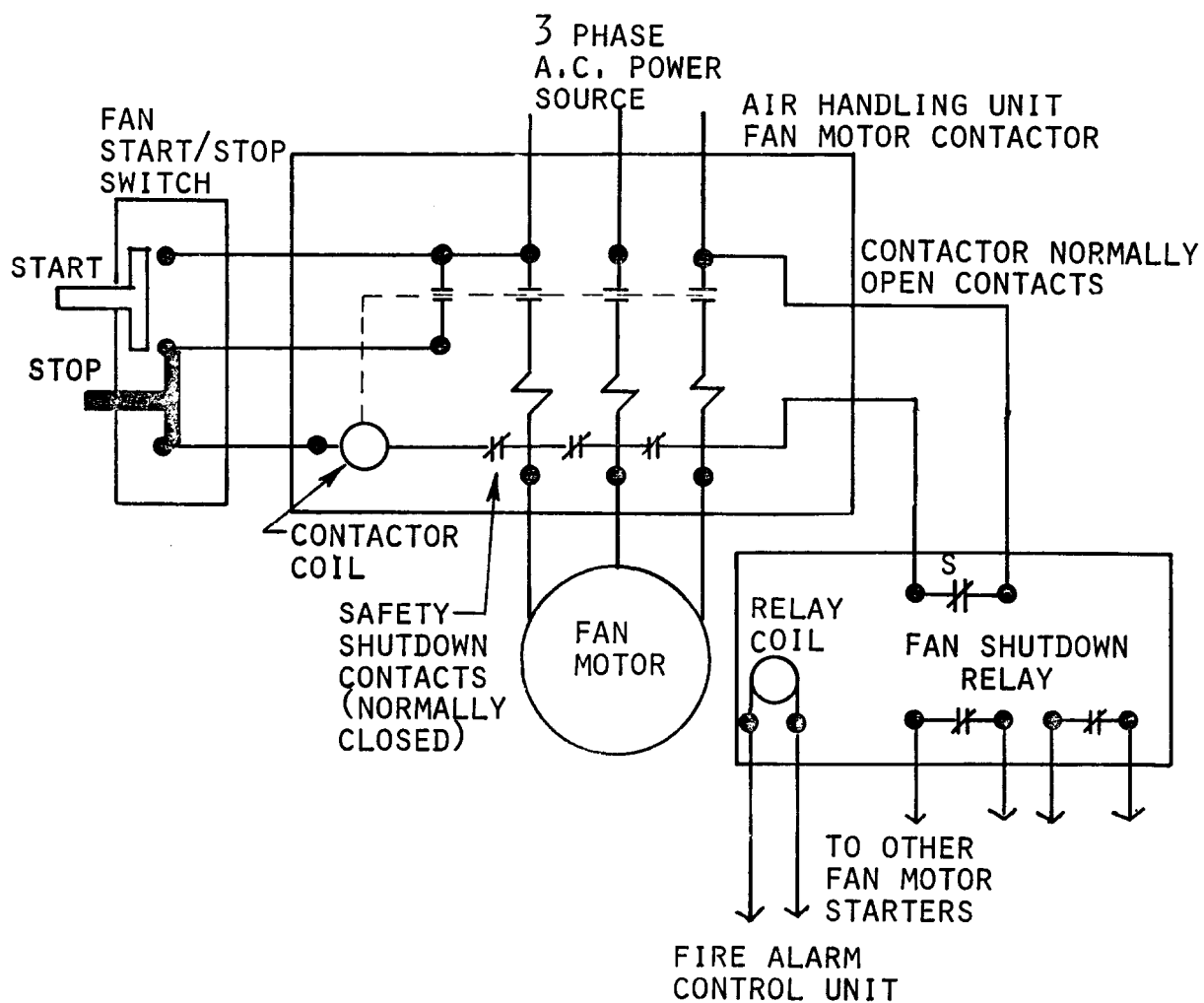


FIGURE 2-10
TYPICAL FAN SHUTDOWN CIRCUIT

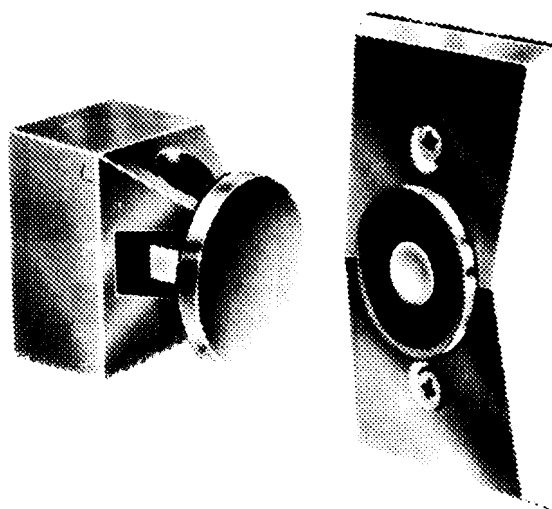


FIGURE 2-11
ELECTROMAGNETIC DOOR HOLDER

- Release of Extinguishing Agent. Auxiliary alarm circuits of the fire alarm control unit can release or activate an extinguishing agent. The interface between the alarm and extinguishing system is usually some form of electromechanical device (such as a solenoid valve) which is energized by the alarm system control unit when there is a fire alarm. For more detail see Chapters 6 through 11 on special hazard extinguishing systems.
- Elevator Recall. Upon initiation of a fire alarm signal, normal elevator operation is interrupted by the alarm control panel. All elevators are returned to a designated floor, with a secondary floor selected if the initiated device is on the primary designated floor. The primary floor is typically the ground or first floor.

2.2.3 Services for Building Alarm Systems.

2.2.3.1 Manual Fire Alarm Service. Figure 2-12 shows a manual fire station, which is also called a manual pull box, a manual fire box or a manual fire alarm. The photograph shows one alarm initiating device. Typically, a manual fire alarm system includes many initiating devices.



The manual fire alarm devices provide a means of manually activating the fire alarm system and are used in all types of fire alarm systems. They may be the only initiating devices provided or they may be used with automatic initiating devices, such as heat or smoke detectors.

Manual fire stations are generally located near main exits from a building or from a floor of a multi-story building and in certain work areas containing unusual fire hazards, valuable equipment, or records subject to fire damage. Paint shops, aircraft repair areas, computer rooms and telephone equipment rooms are examples of such work areas.

FIGURE 2-12
MANUAL PULL BOX

2.2.3.2 Automatic Fire Alarm Service. Automatic fire alarm systems include devices which initiate an alarm without any action on the part of people. The automatic devices sense some symptom or product of a fire such as heat, smoke, infrared or ultraviolet radiation, or waterflow in a sprinkler system.

Automatic fire alarm systems are used to reduce property losses, interruption of operations due to fire, and protect people in their living, working and sleeping areas. Heat detectors are probably the most widely used initiating device for general purpose automatic fire alarm systems.

Generally, smoke, infrared and ultraviolet detectors are faster acting than heat detectors. Fast acting detectors are frequently used in automatic fire detection systems which incorporate an extinguishing agent release function to protect high value or highly combustible storage and work areas, such as computer rooms, aircraft storage and repair areas, explosive processing areas, and telephone equipment rooms. Chapters 6 through 11 describe some of these special systems.

2.2.3.3 Waterflow Alarm. Sprinkler systems may have a local audible device, such as a water motor gong or electric bell, at the sprinkler riser as well as a waterflow sensing device connected to the building alarm system. Detection of waterflow in an automatic sprinkler system is valuable for two reasons: (1) it speeds the summoning of aid in fighting the fire; (2) in the case of a smaller fire which can be put out entirely by sprinklers, it indicates that water is flowing into the building so that when the fire is out the water can be stopped, keeping water damage to a minimum. Waterflow can be sensed by vane type or pressure type switches or water diverted through a water motor gong. A local electrical audible device at the riser normally is electrically independent of the building alarm system.

2.2.3.4 Evacuation Alarm. Evacuation alarms alert people to leave a building threatened by fire and/or notify building occupants to effect manual fire suppression. Evacuation alarm systems have bells, horns, taped messages and/or flashing lights to attract attention in the area. The signals must be distinctive so they are not mistaken for routine signals, for example, audible signals must be distinctly different from base klaxon system audible signals. Frequently evacuation alarm systems have manual fire stations as the only alarm initiating devices, although automatic fire alarm systems can also be used as evacuation alarms.

Where false alarms may be a problem due to vandalism or other unfavorable conditions, a presignal evacuation alarm may be used to inform key personnel, the fire brigade and the fire department of the fire alarm. In a presignal system, if an actual fire is found, a key is used at the manual station operated or at the fire alarm control panel to operate the evacuation alarm signaling devices throughout the building. If no fire is found, the fire alarm control panel can be reset without evacuating the building.

In large buildings, evacuation alarms may sound only on selected floors or sections. Similarly, taped messages may be formulated for a specific section or floor of the building.

2.2.3.5 Sprinkler Supervisory Alarm. Because of the critical nature of sprinkler systems in the fire protection of buildings, it is necessary to continuously monitor conditions which influence the effectiveness of sprinkler systems. Valve position (open or closed), building and water tank temperatures (to avoid freezing), tank water level,

air pressure in dry pipe systems, preaction systems and pressurized water tanks, fire pump power and malfunction are monitored by a sprinkler supervisory alarm system. Control units for sprinkler supervisory alarm systems and fire alarm systems are similar and both are often incorporated into the same control unit.

Sprinkler supervisory alarm initiating devices are switches, just as fire alarm initiating devices are. Normally open switches which close upon alarm are frequently used in end-of-line resistor circuits, though some normally closed switches are used in normally closed loop circuits. However, the alarm initiating devices for sprinkler supervision mount differently and sense different conditions from fire alarm initiating devices.

Indicating devices for sprinkler supervisory alarms are the same as for fire alarms; i.e., horns, bells, chimes, buzzers, lights, annunciators, printers, and CRT and alpha-numeric displays and they are used in the same way as for fire alarms. Usually only one or two audible signal appliances are used because the signal is a maintenance type alarm. It is only used to summon responsible personnel to correct the abnormal condition. Figure 2-5 applies also to supervisory systems if appropriate initiating devices and control unit are substituted. Figures 2-13 through 2-23 show some typical sprinkler supervisory signal initiating devices. Figure 2-24 shows one of the more frequently used supervisory signal initiating circuits.

2.2.3.6 Remote Alarm Signaling. It is usually desirable to connect building alarm systems to a remote receiving station where competent personnel are always on duty who can take the proper action-to extinguish the fire and evacuate the building if necessary or see that necessary maintenance is completed. Most fire alarm and supervisory alarm control panels have provision for connection to a remote receiving station, usually in the form of auxiliary relay contacts which can be connected to operate an alarm transmitter.

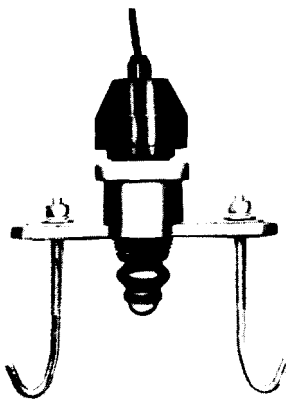


FIGURE 2-13
OS&Y VALVE POSITION
SWITCH (PLUNGER TYPE)

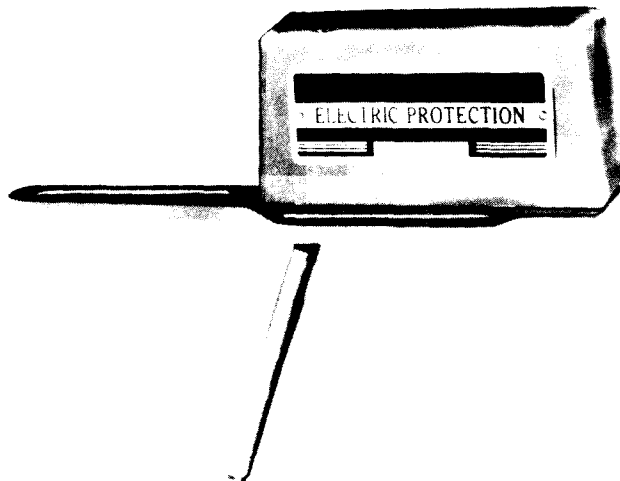


FIGURE 2-14
OS&Y VALVE POSITION
SWITCH (LEVER TYPE)

2.2.3.7 Interlock to Other Building Systems. In some types of buildings it is necessary to interlock the fire alarm system to other building systems. Such interlocks are usually designed into fire alarm systems for large buildings, densely populated buildings, or buildings with special fire hazards. The fire alarm system may provide for operation of any of a number of auxiliary devices, described previously in section 2.2.2.5.

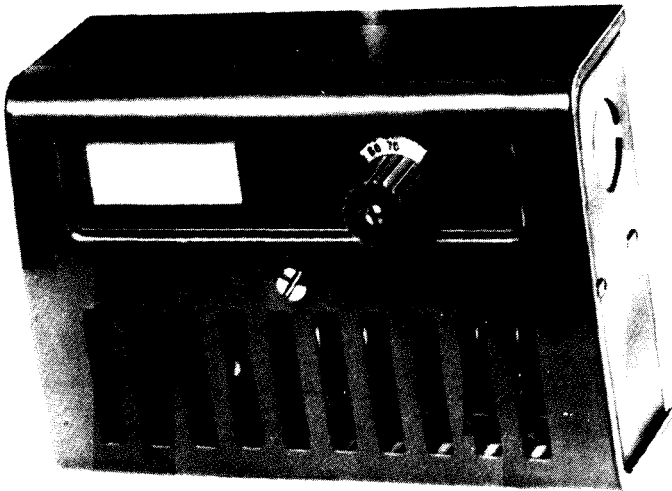


FIGURE 2-15
LOW AIR TEMPERATURE
SWITCH

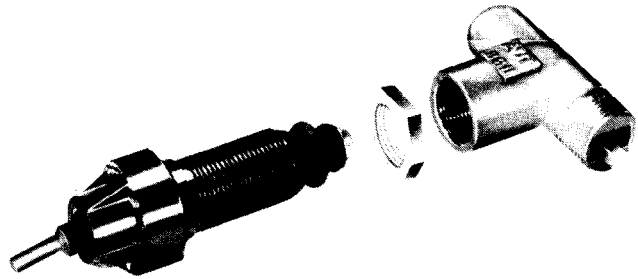


FIGURE 2-16
PIV POSITION SWITCH
(PLUNGER TYPE)

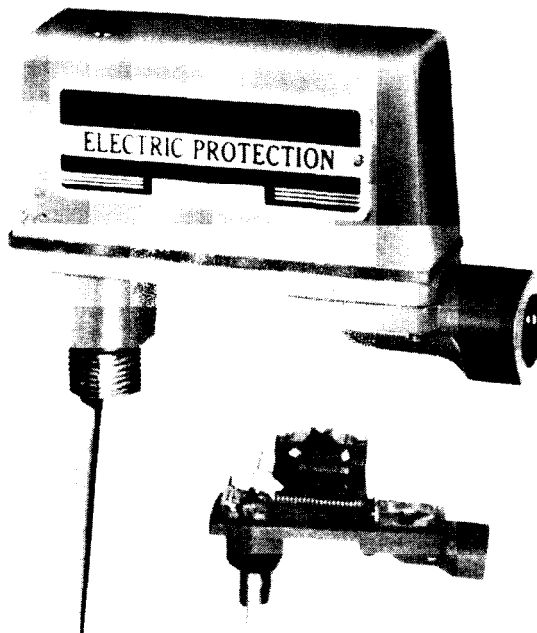


FIGURE 2-17
PIV POSITION SWITCH (LEVER TYPE)

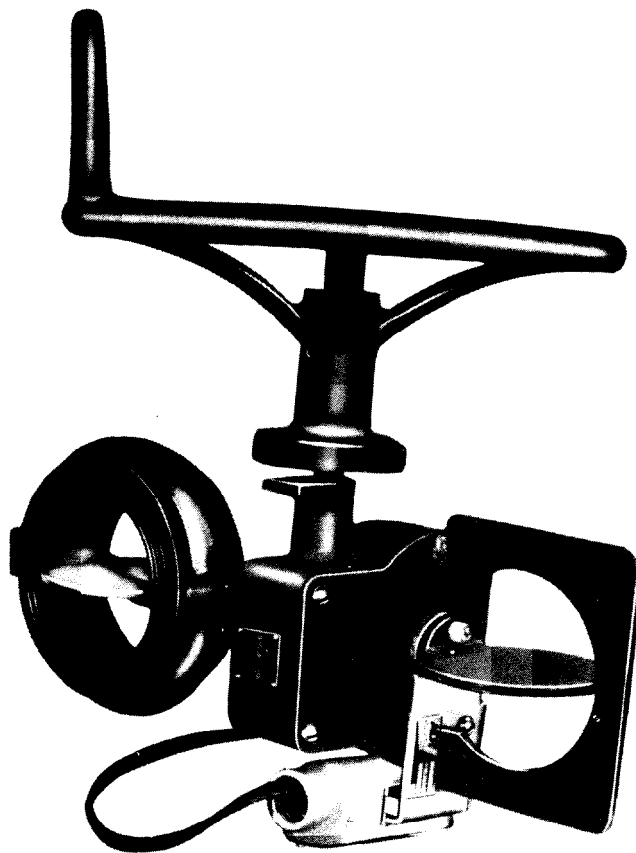


FIGURE 2-18
BUTTERFLY VALVE POSITION SWITCH (MAGNETICALLY OPERATED)

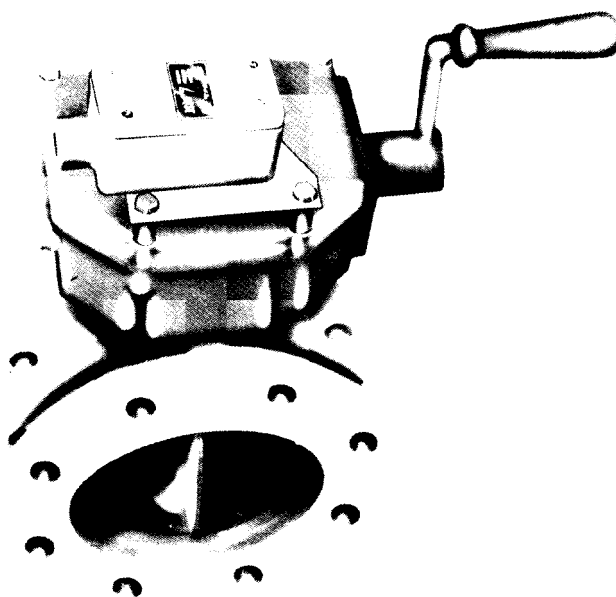


FIGURE 2-19
BUTTERFLY VALVE POSITION SWITCH (MECHANICALLY OPERATED)

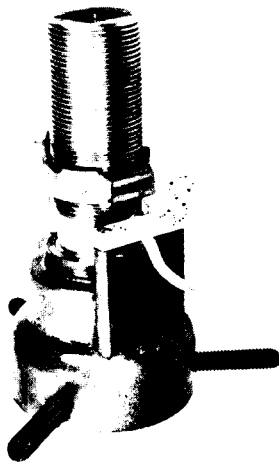


FIGURE 2-20
NON-RISING STEM VALVE
POSITION SWITCH

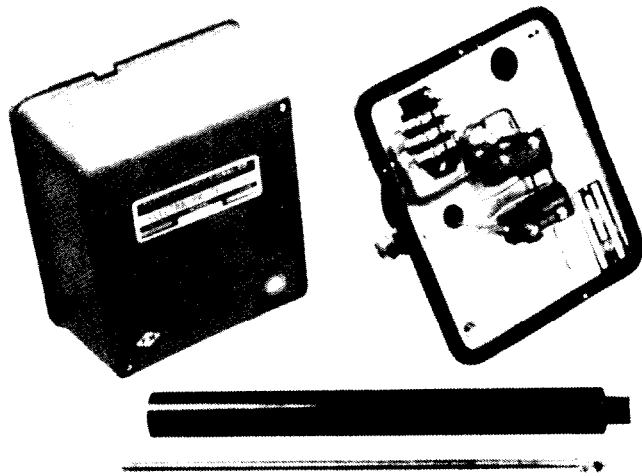


FIGURE 2-21
WATER LEVEL SWITCH
(FLOAT ACTUATED)

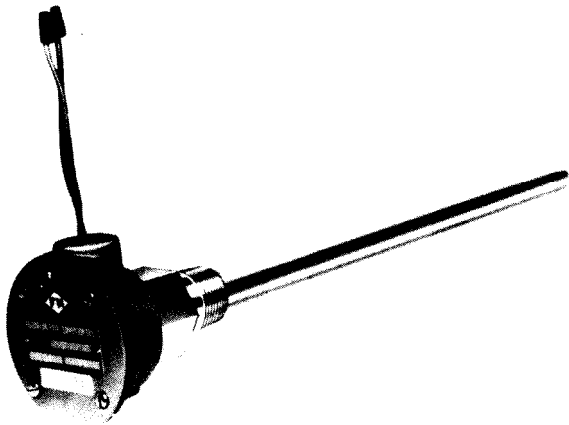


FIGURE 2-22
LOW WATER TEMPERATURE
SWITCH

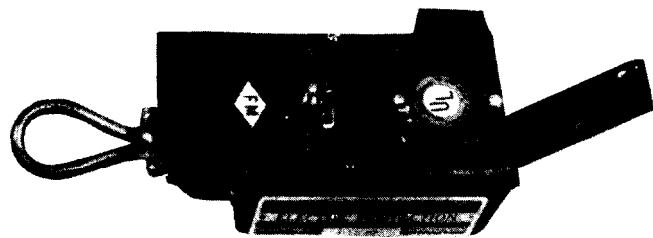
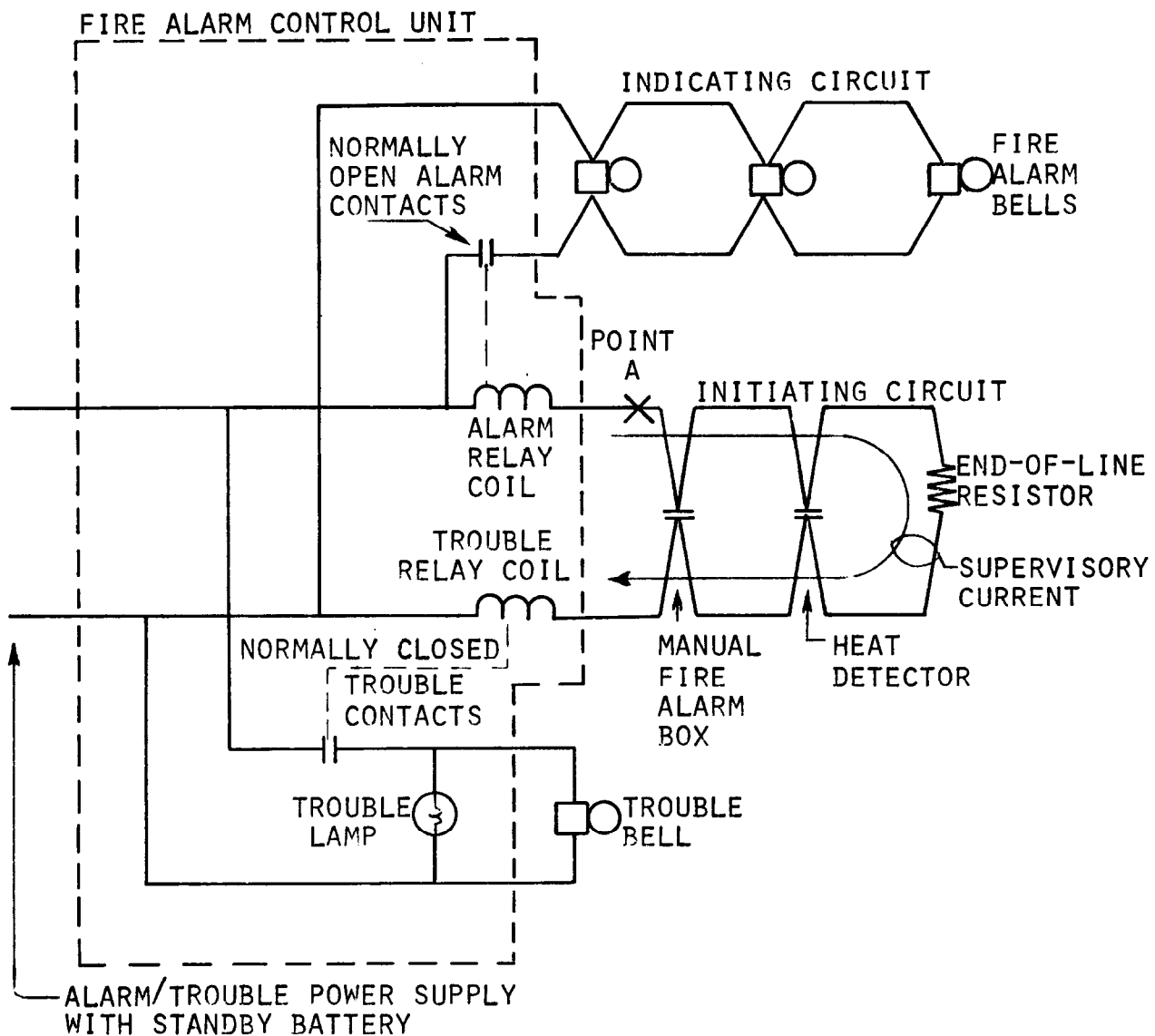


FIGURE 2-23
GATE VALVE POSITION
SWITCH (PLUG TYPE)



NOTE : CONTACTS ARE SHOWN IN THE NO ALARM AND NO TROUBLE CONDITION. ALARM CONTACTS ARE NORMALLY OPEN (N.O.) AND TROUBLE CONTACTS ARE NORMALLY CLOSED (N.C.) WITH NO CURRENT FLOW THROUGH THEIR RELAY COILS. WITH THE ALARM SYSTEM OPERATING A SMALL SUPERVISORY CURRENT ENERGIZES THE TROUBLE RELAY, HOLDING THE TROUBLE CONTACTS OPEN, THE ALARM RELAY REQUIRES A HIGHER CURRENT TO ACTUATE THE ALARM CONTACTS, A BROKEN WIRE AT POINT A DEENERGIZES THE TROUBLE RELAY, CAUSING TROUBLE CONTACTS TO CLOSE, ACTIVATING THE TROUBLE LAMP AND BELL. ACTUATING AN INITIATING DEVICE SHORT CIRCUITS THE END-OF-LINE RESISTOR, INCREASES INITIATING CIRCUIT CURRENT, ENERGIZES THE ALARM RELAY AND RINGS FIRE ALARM BELLS.

FIGURE 2-24
CLASS B SIGNAL INITIATING CIRCUIT

2.3 BASE ALARM SYSTEMS. As for any alarm system, the purpose of a base alarm system is the protection of life, property, and the continuity of operations. By sending alarm signals to a central receiving location, which is continuously staffed by trained persons competent to take necessary action, the protection provided can be more effective than that provided by a number of independent local building alarms.

2.3.1 Classification of Base Fire Alarm Systems

2.3.1.1 Normal Commercial Application of Equipment. Base fire alarm systems may have characteristics similar to local alarm systems (i.e. they may be coded or noncoded, line or low voltage, etc). However, they are most aptly classified by the normal commercial application of the equipment.

- Municipal Type Alarm System. A municipal type alarm system normally provides manual fire alarm signaling service over wiring owned and installed by the city. A city-owned facility, such as a fire station, is the normal location for the alarm monitoring equipment. In a typical military base application, in addition to monitoring alarms from manual fire alarm boxes located on streets, the system also monitors the status of building fire alarm systems and building fire extinguishing systems. A municipal system is also characterized by the following features:

1. It is a coded system, with up to several hundred transmitters connected on a single circuit. Each circuit reports to base alarm headquarters and several such circuits may be used at a single base.
2. Normal operating voltage of each circuit is 48 to 130 volts DC and normal operating current is approximately 100 milliamperes.

- Remote Station Type Alarm System. A remote station alarm system normally provides alarm signaling from automatic alarm or extinguishing systems in buildings. This type system does not usually provide manual fire alarm signaling from manual fire alarm boxes located on streets and, in addition, the system is normally noncoded, providing pilot lamp or meter annunciation of the building where the alarm occurred. This system also has the following additional characteristics:

1. Each noncoded alarm circuit normally operates on light gauge (#22 through #26) telephone type wiring. This wiring, in commercial applications, is leased from the telephone company.
2. One pair of telephone type wires is required for each alarm circuit.
3. Each telephone line circuit normally operates at 12 to 48 VDC and at a current of from 3 to 30 milliamperes.

- Proprietary Type Alarm System. A proprietary alarm system provides signals from various devices in a single large building or from a number of smaller buildings under a single ownership or management to a continuously attended location, controlled and staffed by employees of the protected property. In normal commercial applications, a proprietary alarm system can only be connected to monitor signals from buildings which are owned or operated by a single company or owner. Proprietary alarm systems are very common at Air Force Bases.

The equipment used in a proprietary system may be coded or noncoded, line or low voltage, or may use telephone type or conventional house wiring. Transmission of signals may be accomplished by telephone or conventional house wiring or by radio transmitting equipment.

- Central Station Type Alarm System. Central station alarm systems provide alarm signals from various devices in a single large building or from a number of separate buildings to a continuously attended location owned and operated by an independent party. The system is normally coded and up to 250 separate code transmitters, located in up to 25 different properties, may be connected to a single circuit. Several coded circuits can be monitored at a single central station. Commercially, this is the most widely used method of 24 hour alarm monitoring systems. When an alarm signal is received, the central station notifies the fire department responsible for the area where the building is located. Other characteristics of this type system are:

1. It typically operates over telephone type" (#22 through #26 gauge wires) circuits leased from the telephone company.
2. Each circuit typically operates at 48 to 130 VDC at a current of 3 to 10 milliamperes.

2.3.1.2 Classification by Method of Signal Transmission.

- Radio Call Box. A radio call box system is similar to the municipal type system previously described in terms of the purpose, location of boxes, and auxiliary building alarms.

The main distinctive features of a radio call box system are the method of signal transmission (radio), the redundancy requirements for receivers at the communication center (two complete receiving equipment sets), the testing features required, and the sophisticated signal coding used. Interface panels may be required as the means of connection between the initiating circuits and the radio transmitter.

- Multiplex. Multiplexing is a signaling method which uses simultaneous and/or sequential transmission and reception of multiple signals on one circuit or communication channel. Coding provides positive identification of each signal. Figure 2-25 is a block diagram of a multiplex alarm system.

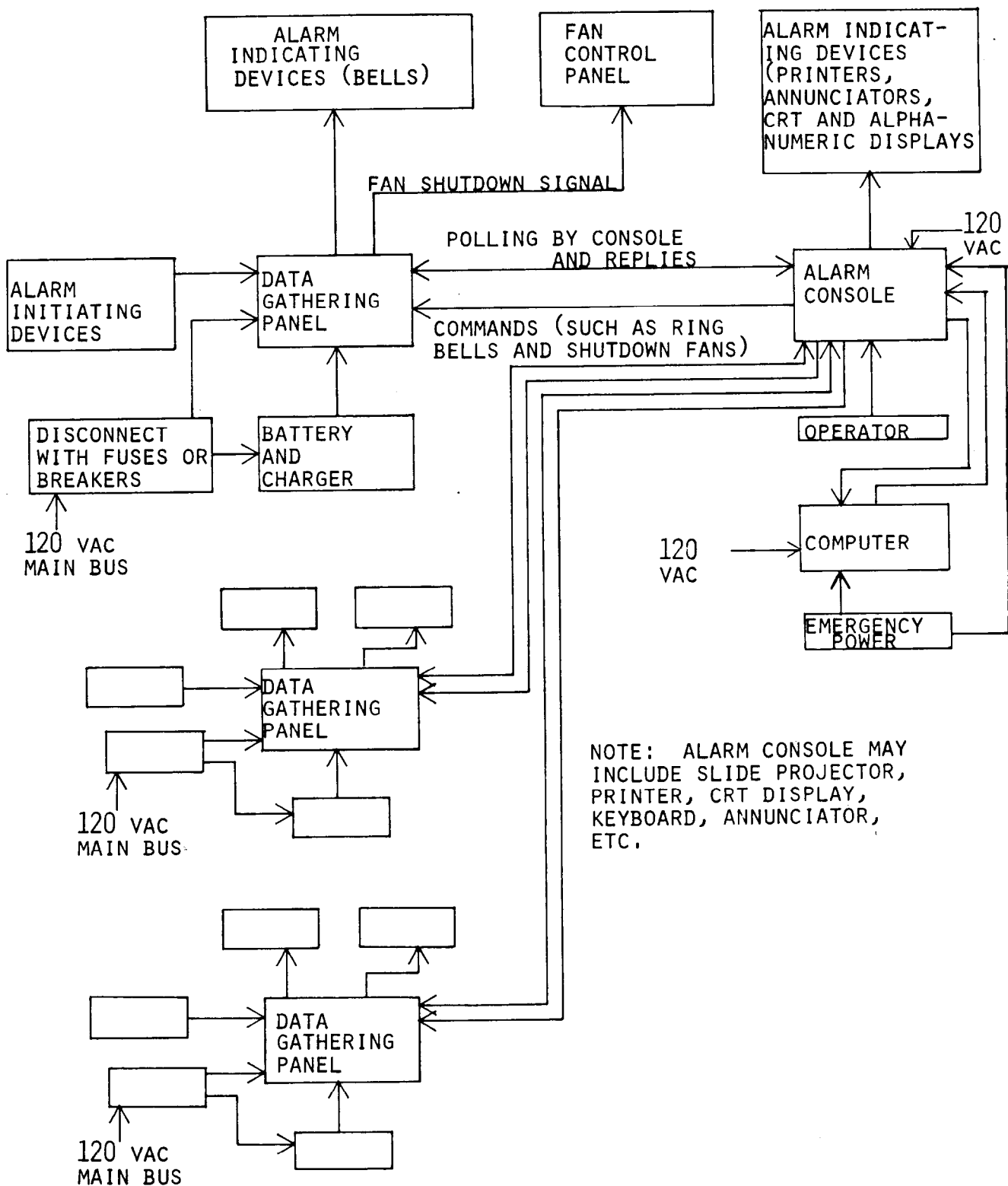


FIGURE 2-25
MULTIPLEX ALARM SYSTEM BLOCK DIAGRAM

Multiplex systems can be of the proprietary or central station type, depending on the Underwriters' Laboratories listing of the equipment used. Generally, equipment listed for central station use can be used for either application while equipment listed for proprietary use can only be used for proprietary applications.

- Hard-Wired. Hard-wired systems are the same as municipal and central station types.
- Telephone Alarm Type (Automatic Dialers). Automatic dialers use existing telephone circuits to actually place a telephone call to a fire communication center.

If permitted by the local authorities, an automatic tape dialer makes the call to the fire emergency number. A tape recorded message to the effect that "There is a fire in progress at 123 Elm Street," is played over the telephone to the fire dispatcher. The message is repeated several times and then the automatic dialer hangs up.

For an automatic digital dialer, an unlisted telephone number is **set** aside for exclusive use in receiving alarm messages at the fire communication center. A special receiver is installed which answers the calls, converts the coded message to a display and/or printout identifying the location sending the message, the type of alarm (fire, burglar, medical emergency, etc.) and the time received. The total time from answering the call to hanging up is much shorter for the digital dialer than for the tape dialer. Many dialers would be arranged to call one receiver in an established alarm system.

2.3.1.3 Classification of Base Alarm Systems According to the NFPA

- Municipal Fire Alarm Systems. According to NFPA 1221-1984, a municipal fire alarm fulfills "two principal functions: that of receiving fire alarms or other emergency calls from the public and that of retransmitting these alarm and emergency calls to the fire companies and other interested agencies".
- Remote Station Alarm Systems. In NFPA 72C-1986, a remote station alarm system is defined as ". . . a system of electrically supervised circuits employing a direct circuit connection between signaling devices at the protected premises and signal receiving equipment in a remote station, such as a municipal fire alarm headquarters, a fire station, or other location acceptable to the authority having jurisdiction. "
- Proprietary Alarm Systems. A proprietary alarm system is described in NFPA 72D-1986 as: "A protective signaling system under constant supervision by competent and experienced personnel in a central supervising station at the property protected. The system includes equipment and other facilities required to permit the operators to test and operate the system and, upon receipt of a signal, to take such action as shall be required under the rules established for their guidance by the authority having jurisdiction. The system shall be maintained and tested by owner personnel or an organization satisfactory to the authority having jurisdiction."

- Central Station Alarm Systems. In NFPA 71-1985, a central station alarm system is "A system, or group of systems in which the operations of circuits and devices are signaled automatically to, recorded in, maintained, and supervised from an approved central station having competent and experienced observers and operators who shall, upon receipt of a signal, take such action as shall be required by this standard. Such systems shall be controlled and operated by a person, firm or corporation whose principal business is the furnishing and maintaining of supervised signaling service."

2.3.2 Base Alarm System Components.

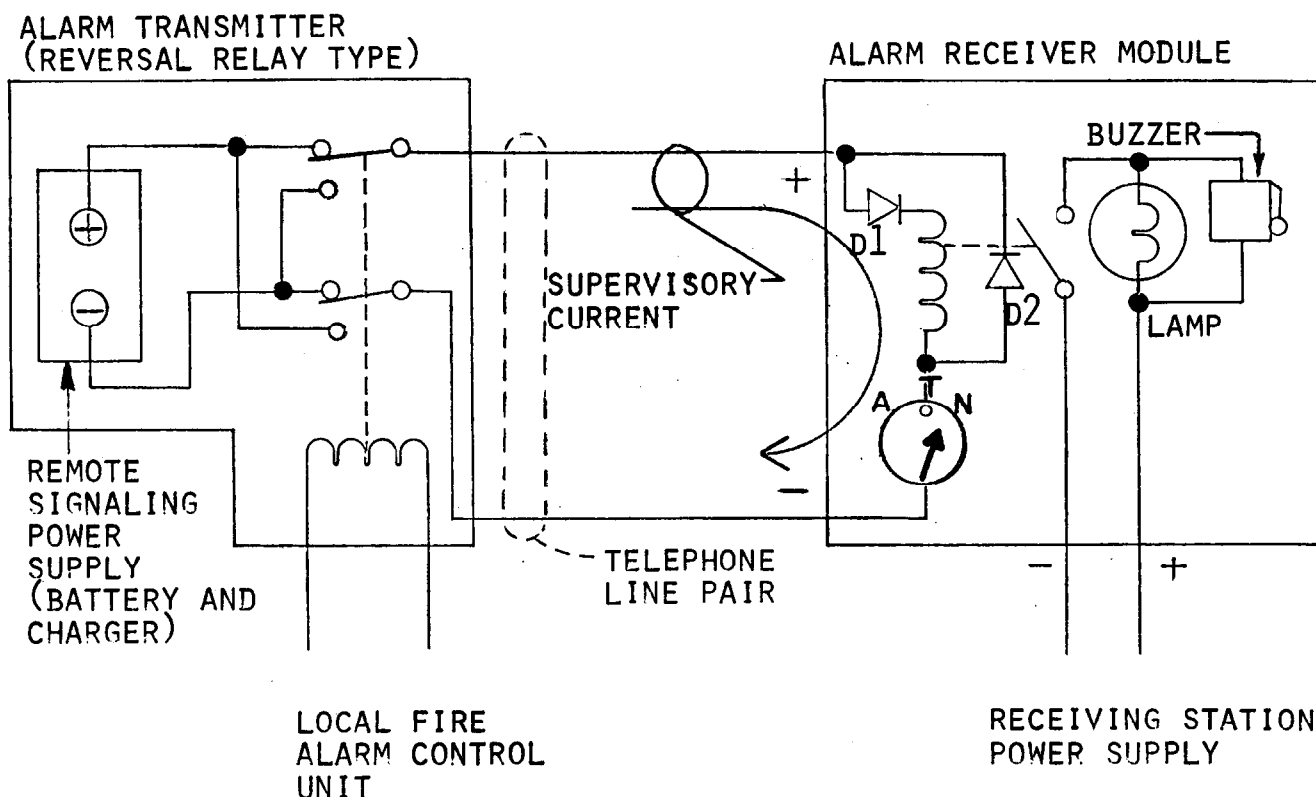
2.3.2.1 Signal Transmitters. A common fire alarm transmitter is the telegraph type with ground connection, commonly known as the McCulloh transmitter. The McCulloh coded fire alarm transmitters are frequently used for automatic fire alarm systems. The McCulloh transmitter is found in many other forms, often in combination with initiating devices, such as manual fire stations and waterflow switches. The McCulloh transmitter sends a coded series of pulses which identifies the particular transmitter.

Base alarm systems also use reversal transmitters. The transmitter causes the DC polarity (plus and minus) of a pair of wires to be reversed from the normal condition for the alarm condition. Figure 2-26 shows a typical reversal (relay) transmitter schematic. Receiving equipment and telephone lines required for this (reversal) type transmitter are different from the equipment and telephone lines required for McCulloh system.

The data gathering panel in a multiplex type system may be considered an alarm transmitter. It is the means of sending the alarm information from the vicinity of the alarm initiating devices to the main alarm receiving console. The data gathering panel continually scans the initiating device circuits connected to it and temporarily stores any change in device status. The alarm console, meanwhile, is continually scanning the data gathering panels for changes in status. On the next scan after the change in status, the alarm console picks up the stored information from the data gathering panel. The data gathering panel is sometimes called a transponder to more accurately describe the transmit and respond functions.

2.3.2.2 Signal Receiving Facilities. The equipment installed in a receiving facility varies, depending on the exact type of base system, but certain characteristics of the receiving facility are common to all the types of base systems. The alarm receiving equipment is normally powered by AC line voltage with a secondary power source to provide at least 4 hours of equipment operation if the AC power fails. A continuously available generator may take the place of the rechargeable batteries.

Usually the communication center is located in a fire station with direct telephone and radio communications with other fire station(s) served by its communications facilities. When received, fire alarms may directly ring bells in the living and working areas of the fire station(s). Detailed information on location, type, and size of fire is announced over a paging system and/or radio to the firefighters as they move to the trucks and as the trucks move toward the fire.



NOTE: POLARITY AT ALARM RECEIVER MODULE AND RELAY CONTACTS ARE SHOWN IN THE NO ALARM CONDITION. FOR AN ALARM, THE TRANSMITTER CONTACTS TRANSFER, REVERSING VOLTAGE AND CURRENT POLARITY OF THE TELEPHONE LINE PAIR. THE ZERO CENTERED METER IN THE RECEIVER MODULE CHANGES INDICATION FROM (NORMAL) TO A (ALARM), CURRENT FLOW THROUGH THE RECEIVER MODULE RELAY IS BLOCKED BY DIODE D1 AND THE RECEIVER MODULE RELAY CONTACTS CLOSE, LIGHTING THE LAMP AND SOUNDING THE BUZZER. THE CURRENT FOR METER ALARM INDICATION FLOWS THROUGH THE METER AND DIODE D2.

FIGURE 2-26
CLASS B REMOTE SIGNALING CIRCUIT

2.3.2.3 Signal Receivers. Alarm receiving equipment processes the incoming signal and changes it to a form which can be used by the signal recording device or computer, if used. Depending on the sophistication of the receiving equipment, it may automatically display varying degrees of detailed information. Generally, the multiplex or radio call box type system, coupled with a computer, automatically displays the detailed information. McCulloh systems also have been coupled with computers, which automatically decode the pulsed signal and display appropriate emergency information.

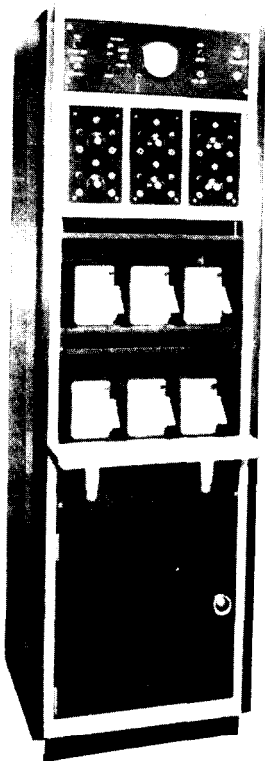


FIGURE 2-27
MCCULLOH SIGNAL RECEIVING EQUIPMENT

- McCulloh and Municipal Type Receivers. McCulloh and municipal type receivers are similar. The receiver consists of a cabinet containing relays and switches to accommodate the types of circuit faults that might occur, paper tape registers for recording signals, indicator lights and audible signals to show that a signal is coming in or AC power is lost, and a meter to indicate current in the transmission circuits. The cabinet may serve up to 12 circuits and the meter may be switched from one circuit . . . to another for testing. Figure 2-27 illustrates a typical set of McCulloh receiving equipment.

- Radio Call Box Receivers. A radio call box receiver incorporates a radio receiver and signal processor for decoding radio signals. When this type system is the main or only base fire alarm system provided, the receiver and associated visual display, printer, audible signals, control switches, power supply, clock, standby battery, charger, signal strength meter, and memory unit are normally mounted in a console or cabinet assembly. Some components, such as battery and charger might be housed in a separate cabinet or room. The main receiving antenna is mounted separately at some high point in or on the building to obtain maximum line-of-sight signal strength. Figure 2-28 shows a typical radio call box receiver console incorporating two complete receivers.

The display, which provides information on the location and type of alarm, information may be of the graphic or alpha-numeric type. The memory unit stores addresses identifying numbers for all the boxes in the system. When a signal is received, it is compared with memory information to determine if the signal is a valid one from a known call box. The memory is also used once a day to determine if any call boxes failed to transmit the required daily test signal; or reported a low battery or other trouble condition. Depending on the equipment manufacturer, the test signal may be initiated by a timer in the call box or it may be commanded by the receiving console in systems which are computer based (in which radio boxes and the base station are actually transmitter/receivers). Printers maintain a permanent record of all signals and acknowledgments of signals.

In order to satisfy NFPA 1221, a complete redundant set of receiving equipment is required as a backup. Both sets must be continuously operating, except during the emergency repair of one set.

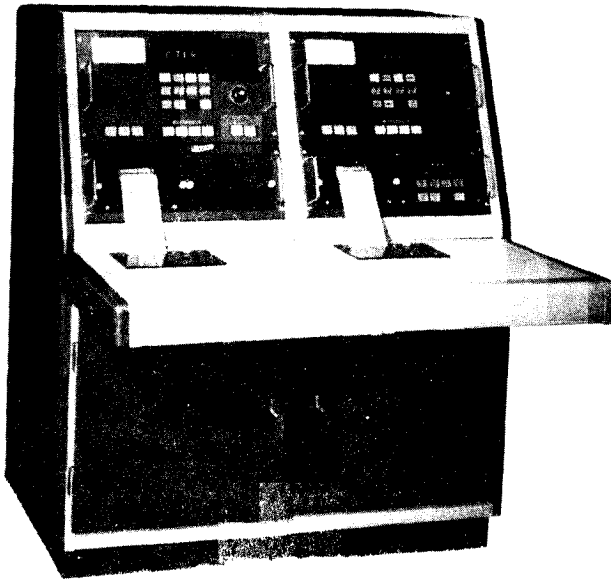


FIGURE 2-28
RADIO CALL BOX SIGNAL
RECEIVER CONSOLE

- **Multiplex Receivers.** A multiplex receiver is physically similar to the radio call box receiver. Frequently a multiplex receiver will also have an associated keyboard and CRT. (Figure 2-4 shows a typical installation.) The keyboard is used to enter new emergency information into the console memory. Control switches can be used to request information on a particular zone, which is then displayed on the CRT or projected on a screen by a slide projector. Multiplex systems also have annunciation and alpha-numeric displays. However, unlike radio call box systems, daily test signals are not required in multiplex systems since the receiving equipment is in almost constant contact with the data gathering panels. Printers are generally used with multiplex systems to obtain a permanent record of date and time the signals are received and a record of acknowledgments of signals.

- **Remote Station Receivers.** Remote station receivers are characterized by small modules, each of which corresponds to an alarm signal source. Each module has indicator lights and/or a meter to indicate alarm, normal, and trouble conditions. The power supplies for the individual signals are usually located at the signal sources, so the only power supply required at the receiver is for operating indicator lights and a common audible signal device.

2.3.2.4 **Signal Recorders.** Through the last 40 to 50 years, signal recorders have developed tremendously. Some of the earliest models are still in operation, so a wide range of types is found in existing base alarm systems.

The McCulloh tape register is one of the more widely used signal recorders in existing systems. Some of the older models use a spring wound motor to move the paper tape through the recorder. A hole is punched in the tape for each pulse of the coded signal. Newer models use electrical means to move the paper tape through the register and the pulse marks are generated by solenoid action. For each pulse, the solenoid may cause a wiggle in a line drawn by a pen, print a spot, or punch a hole in the paper tape. Regardless of the type, the used portion of the tape is usually stored on a motor-driven take-up reel. Some registers record the signals for a number of separate circuits on the same tape.

Several types of printing recorders are used in larger systems. The large number of signals received makes the simpler, one circuit tape registers impractical because of the excessive amounts of paper which would be used.

2.3.2.5 Power Supplies. Numerous power supplies are associated with the base alarm system. Most of these will be small power supplies at the protected sites, used for powering the individual alarm transmitters, for tripping a local-energy-trip type municipal transmitter, or for powering remote signaling circuits. In addition, a larger power supply is needed at the alarm receiving location for powering the receiver(s) and other equipment essential to the alarm receiving and fire equipment dispatching operation.

- Power Supplies at the Protected Building. At the protected building, individual items of equipment may have separate power supplies or all power may be provided by the local fire alarm control panel power supply. Frequently, the power supply for the individual transmitter or remote signaling pair of wires is a rechargeable, sealed nickel-cadmium or lead-acid battery which powers the load through a current-limiting resistor. The battery charge is maintained by a simple charging circuit which constantly "trickle-charges" (low rate constant current charging) a nickel-cadmium battery or "float charges" (constant voltage charging in which the current tapers off to zero) a lead-acid battery.

Electrically powered code transmitters may also have a trouble signal power supply, similar to the main supply, which insures that a trouble signal is transmitted in case of failure of the main supply. Generally, secondary power supplies at the protected building are designed to provide 24 hours of operation if the AC power is disconnected.

- Receiving Station Power Supply. The fire alarm receiving station has primary and secondary power. Primary power is a reliable commercial (AC) power source or an engine driven generator. Secondary power may be storage batteries with rectifier/charger. If both types of primary power are available, the battery capacity must be sufficient to operate the system under maximum normal load for four hours. If the generator is not available, the battery capacity must be increased to allow operation for 24 hours.

There are many other allowed combinations of primary and secondary power sources, described in NFPA Standard No. 72D. Maintenance and testing aspects for all combinations are essentially the same.

2.3.3 Services Provided by Base Alarm Systems.

2.3.3.1 Monitoring Fire Alarm Signals. The primary purpose of the base fire alarm system is to monitor fire alarm signals and relay the alarms to the affected fire station(s). Base system monitoring of signals is more effective than a purely local audible fire alarm, especially during

nonworking hours. The operators/dispatchers receiving the alarm are trained persons, competent to take necessary action. Local alarms, if noticed, may be received by an untrained passerby who may take inappropriate or ineffective action.

2.3.3.2 Monitoring Fire Trouble Signals. Fire trouble signals indicate problems in local fire alarm systems which could reduce their effectiveness or render them inoperative. Prompt action to correct the problem is necessary in order to restore fire alarm protection. Fire trouble includes circuit and equipment faults and power failure.

2.3.3.3 Monitoring Sprinkler Supervisory Signals. A sprinkler supervisory signal indicates that an abnormal condition exists which may impair the effectiveness of sprinklers. Some type of maintenance action is required in order to correct the condition and restore the sprinkler system(s) to full effectiveness. If the supervisory devices were carefully identified at installation, the maintenance person dispatched can be fully prepared to correct the abnormal condition causing the signal.

2.3.3.4 Monitoring Other Signals. Sometimes security alarms and/or medical emergency alarms are connected to produce signals at the same receiving facility as fire, fire trouble, and supervisory signals. If two or more signals originate at the same location, some plan for establishing priorities and eliminating confusion of signals is necessary.

2.4 SUPERVISED CIRCUITS. Because of the critical nature of fire alarm systems, a feature known as "electrical supervision" has been designed into these systems. Alarm systems must be in service at all times; electrical supervision causes a warning (trouble) signal that some potential or actual electrical problem exists in the alarm system. This trouble signal is clearly distinguishable from a fire alarm signal.

2.4.1 Classes, Types, and Applications Supervision. There are several methods of circuit supervision used in fire alarm systems. The particular method used may depend on the type of fire alarm system (municipal, local, proprietary, etc.), type of circuit (signaling or initiating) and desired capacity of the circuit (in terms of number of devices or zones connected by the circuit). The variety of circuit supervision methods can be grouped into three categories, based on circuit performance despite the presence of an abnormal condition, such as single open, ground or wire-to-wire short.

- Category 1: Circuit indicates trouble when abnormal condition is detected.
- Category 2: Circuit indicates trouble when abnormal condition is detected. Alarm transmission/receipt may be possible.
- Category 3: Circuit indicates trouble when abnormal condition is detected. Alarm transmission/receipt still possible.

Category 1 circuits have traditionally been referred to as Class B circuits. Recently, NFPA 72D refers to "Styles" rather than "Classes". For proprietary signaling system, for which NFPA 72D is applicable, a category 1 circuit is either Style A in the case of an initiating device circuit, (IDC) or Styles 0.5 and 3.5 if a signaling line circuit (SLC).

Category 2 circuits are a combination of traditional Class A and Class B circuits. For proprietary signaling systems, IDC Styles B and C and SLC Styles 1, 2, 3, 4 and 4.5 are all category 2 circuits. Finally, category 2 circuits, have been traditionally referred to as Class A circuits. NFPA 72D now identifies the category 2 circuits as Styles D and E for IDC's and Styles 5, 6 and 7 for SLC's.

Since circuit types are already referenced as "Classes" and "Styles" in NFPA documents and other publication use of "Categories" as a third means of designation for this manual would only add to the confusion. Thus, circuit categories will be as Class A or B for the purpose of this manual. This designation is used due to the traditional and widespread acceptance of this terminology. Those individuals working solely on proprietary signaling systems should refer to the discussion immediately preceding this paragraph to convert from the "Class" designation to "Style". The simplest of the more commonly used circuits is the Class B circuit and it is discussed first.

2.4.1.1 Class B Supervision Applications. A Class B supervised fire alarm circuit provides a warning trouble signal if a fault occurs in the circuit and may not function for its original alarm purpose until the fault is corrected, depending on the location and type of fault.

- Initiating Circuit. Figure 2-24 shows a typical Class B alarm initiating circuit. A continuous small electrical current, supplied by the fire alarm control panel, flows through the series loop formed by one side of the initiating circuit, the end-of-line resistor, and the other side of the initiating circuit as indicated by the arrow. The fire alarm control panel reacts to this constant low current as a no-alarm or normal condition.

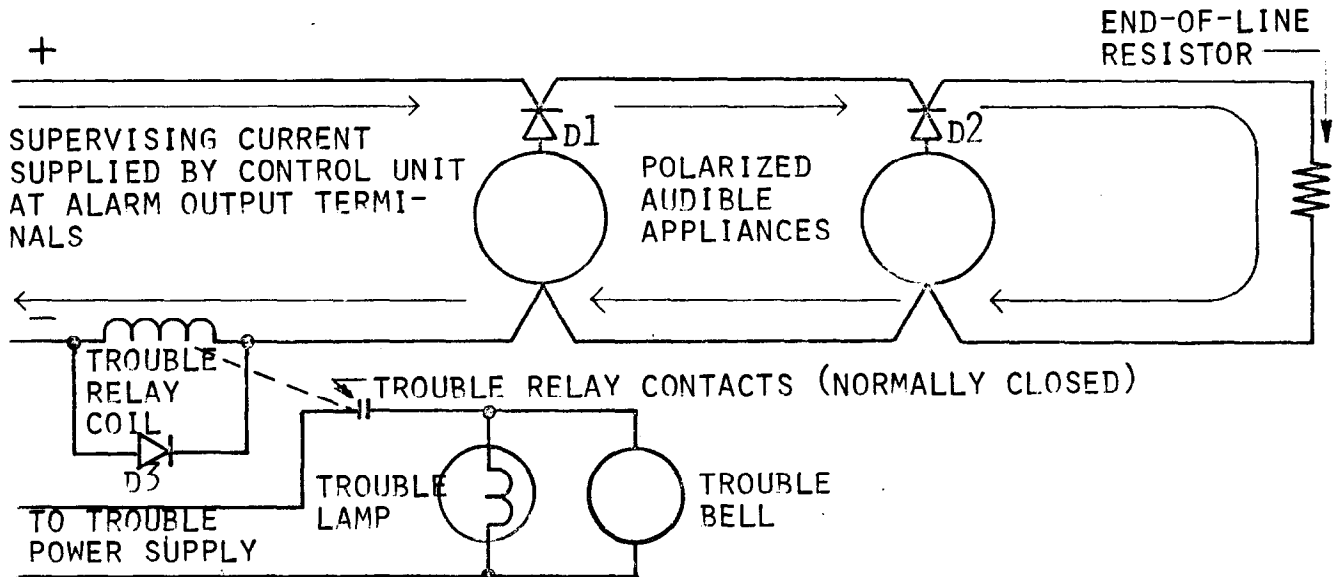
Under normal conditions, the alarm and trouble relay coils have the same low value of supervisory current flow. For the alarm relay, this value is inadequate to close its normally open contacts. The trouble relay is more sensitive and is energized by the supervisory current and the normally closed contacts are held open. If the supervisory current drops to zero because of a broken wire anywhere in the initiating circuit, the trouble relay is deenergized and its contacts close, causing an audible and visual trouble signal.

If no wires are broken, closing the contacts of an initiating device provides a low resistance current path, short circuiting the end-of-line resistor and increasing the alarm relay coil current. The alarm relay is energized, closing its contacts and ringing the alarm bells. Continued fire alarm operation with a broken wire depends upon the location of the break and the actuated initiating device.

- Remote Signaling Circuit. Figure 2-26 shows a Class B remote signaling circuit, commonly used for fire department connection to individual building alarm systems. The alarm transmitter can either be part of the fire alarm control cabinet or be operated by it. Figure 2-26 shows the no alarm condition.

If, instead of an alarm, one of the two telephone wires is broken, the supervising current supplied by the transmitter will drop to zero closing the receiver module relay contacts, lighting the lamp and sounding the buzzer. The meter indication will be zero, marked on the meter face as trouble. If a telephone wire is broken before an alarm condition occurs, the reversal of voltage by the alarm transmitter will not change the "no current" condition at the alarm receiver and no alarm will be caused. The trouble condition will continue until the broken wire is repaired.

- **Indicating Circuit.** Figure 2-29 shows a Class B alarm indicating circuit. During normal conditions a small current flows constantly through the loop formed by the two sides of the circuit and the end-of-line resistor.



NOTE : POLARITY AND CONTACTS ARE SHOWN IN THE NO ALARM CONDITION. DIODES D1 AND D2 ARE INCORPORATED IN THE AUDIBLE APPLIANCE HOUSINGS. THE END-OF-LINE RESISTOR IS MOUNTED AT THE LAST AUDIBLE APPLIANCE AND CLEARLY MARKED. CURRENT THROUGH THE AUDIBLE APPLIANCES IS BLOCKED BY THE DIODES D1 AND D2. THE TROUBLE RELAY IS ENERGIZED WITH THE SMALL SUPERVISORY CURRENT, HOLDING THE TROUBLE CONTACTS OPEN.

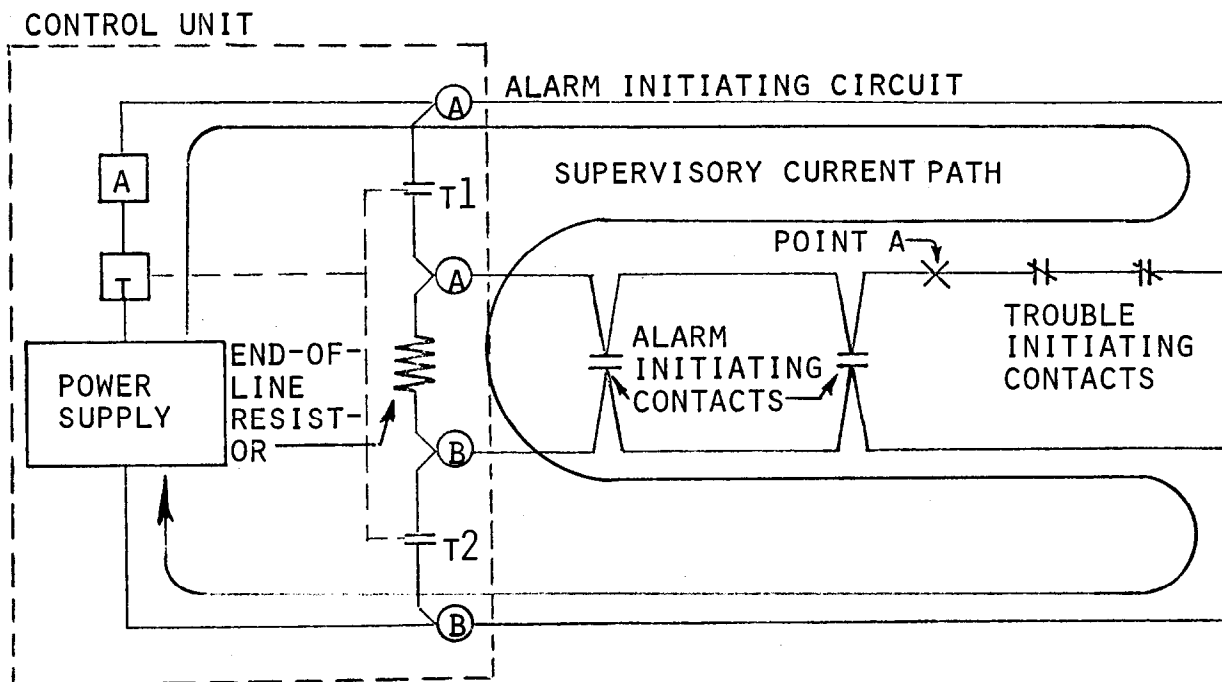
FOR AN ALARM, THE ALARM OUTPUT VOLTAGE FROM THE CONTROL UNIT IS REVERSED BY THE SAME METHOD AS SHOWN IN FIGURE 2-26. DIODE D3 PROVIDES A HIGH CURRENT FOR ACTIVATING THE AUDIBLE APPLIANCES BYPASSING THE CURRENT LIMITING INFLUENCE OF THE TROUBLE RELAY COIL.

FIGURE 2-29
CLASS B ALARM INDICATING CIRCUIT

For an alarm condition, the voltage and current supplied by the fire alarm control panel reverse and the current is no longer limited to a small "supervising" current. Current flows through the polarized audible appliances now as well as the end-of-line resistor and the audible appliances sound the fire alarm.

As in the circuit in Figure 2-26, if one of the circuit wires is broken during otherwise normal conditions, the supervising current stops and a trouble condition is indicated at the fire alarm control panel. Also, as in the other Class B circuits, the portion of the circuit beyond the broken wire (in this case, the audible devices beyond the break in the wire) will not operate in the event of an alarm.

2.4.1.2 Class A Supervision Applications. A Class A supervised fire alarm circuit provides a trouble signal and continues to operate as an alarm circuit after one fault has occurred in the wiring.



Ⓐ AND Ⓑ - ALARM INITIATING CIRCUIT TERMINALS IN CONTROL UNIT

Ⓐ - ALARM (SHORT CIRCUIT) SENSITIVE RELAY COIL

Ⓙ - TROUBLE (OPEN CIRCUIT) SENSITIVE RELAY COIL

T1 AND T2 ARE CIRCUIT CONDITIONING CONTACTS OF THE TROUBLE RELAY

NOTES : CONTACTS ARE SHOWN IN THE NORMAL OPERATING CONDITION, A BREAK IN THE WIRING AT POINT A CAUSES ONE SIDE OF THE ALARM INITIATING CIRCUIT TO BECOME ISOLATED FROM THE END-OF-LINE RESISTOR. A TROUBLE SIGNAL RESULTS, AND CIRCUIT CONDITIONING (TROUBLE) RELAY CONTACTS T AND T2 CLOSE. THIS CONNECTS THE SIDE OF THE ALARM INITIATING CIRCUIT, WHICH WAS ISOLATED BY THE BREAK, TO THE END-OF-LINE RESISTOR, AN ALARM CONTACT CLOSURE SHORT CIRCUITS THE END-OF-LINE RESISTOR AND CAUSES AN ALARM SIGNAL. TROUBLE INITIATING CONTACTS ARE OPENED BY ABNORMAL CONDITIONS SUCH AS LOSS OF SMOKE DETECTOR POWER OR AN OPEN WATERFLOW DETECTOR COVER.

FIGURE 2-30
CLASS A ALARM INITIATING CIRCUIT

- Initiating Circuit. In Figure 2-30, a typical Class A alarm initiating circuit is illustrated. A continuous supervisory current supplied by the fire alarm control unit flows through the two circuit loops (circuit loops are shown as the wiring between terminals A and A, and terminals B and B. All four terminals are located at the fire alarm control unit). Typically one A and B pair of terminals are the "feed" or "supply" pair for the initiating circuit. If the outer A and B terminals are the plus (+) and minus (-) supply pair, respectively, the inner A and B pair are the "return" pair. Typically, a trouble relay coil in the fire alarm control panel is energized by the supervisory current. If a wire in the A loop breaks, the trouble relay is deenergized, causing two results: (1) audible and visual trouble signals occur; (2) the damaged circuit is automatically conditioned so that the total circuit is still active as an alarm circuit. All alarm initiating devices are still effective if alarm conditions occur. With a broken wire in the A loop, both ends of the A loop become plus (+) feed or supply terminals. There is no longer an A loop return terminal, since current cannot flow in the A loop with the broken wire.

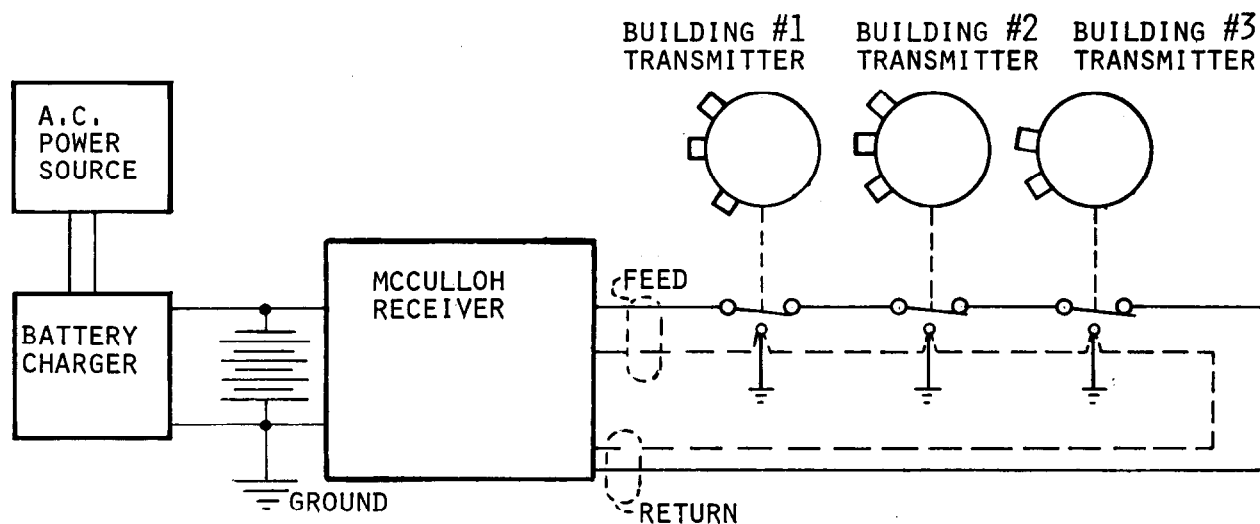
If alarm conditions occur, any one of the initiating device switches could close, a current path between A (+) and B (-) loops would occur, and the fire alarm control unit would react by sounding audible appliances and/or transmitting a fire alarm signal to a remote receiving station.

- Remote Signaling Circuit. It is also frequently desirable to have the Class A characteristic in a circuit for connecting a building fire alarm control panel to the fire department or to some other alarm receiving point. Figure 2-31 shows a typical simplified Class A remote signaling McCulloh circuit. It is similar to the Class A initiating circuit. The main differences are the use of earth ground by the McCulloh circuit for one of the circuit loops and the use of coding to identify which building is producing the alarm. Otherwise the Class A operation is the same.

In an actual installation, a second circuit loop may be substituted for earth ground. The use of earth ground reduces the quantity of wire required, since the earth is actually used as an electrical conductor between the alarm transmitters and the receiving station. The identifying code of each transmitter is produced by rotation of a code wheel with a unique number or sequence of groups of teeth which operate the coding contacts. The alarm is received as a series of pulses which identify the location of the transmitter.

- Indicating Circuit. Figure 2-32 shows a Class A Alarm Indicating Circuit. It is quite similar to the Class B version shown in Figure 2-29. The Class A circuit has all the bells polarized and the supervisory current operates a relay in the fire alarm control panel. The relay, connected to the return terminal, deenergizes if a wire breaks and causes the audible and visual trouble signals. Bells on both sides of the break are still operative. This conditioning to keep the bells operative is similar to that for a Class A fire alarm initiating circuit.

2.4.1.3 Series Normally Closed Circuit Supervision. Series normally closed circuits are not usually found in recently installed fire alarm systems, but many of these circuits are in older systems. Normally closed series initiating circuits for the municipal shunt trip box or transmitter and some series manual box circuits for directly shutting down fans and closing fire doors are still being installed in new systems. Examples of the older series initiating circuit and indicating circuit are described here.



NOTE: MCCULLOH RECEIVING LOCATION HAS CONTINUOUS A.C. POWER SOURCE, STANDBY BATTERY AND CHARGER AND/OR EMERGENCY GENERATOR, RECEIVING EQUIPMENT HAS SIGNAL RECORDER(S), RELAYS AND SWITCHES FOR RECORDER CONTROL AND CIRCUIT CONDITIONING, INDICATING LAMPS, BUZZERS AND METERS)

A SINGLE FAULT ON THE SIGNALING CIRCUIT (OPEN OR GROUND) CAUSES A TROUBLE SIGNAL AT THE RECEIVER, OPERATION OF A SELECTOR SWITCH TO THE PROPER POSITION SILENCES THE TROUBLE SIGNAL AND CONDITIONS THE SIGNALING CIRCUIT SO THAT ALL SIGNALS CAN STILL BE RECEIVED, THE TYPE OF FAULT IS INDICATED BY THE SWITCH POSITION WHICH SILENCES THE TROUBLE SIGNAL,

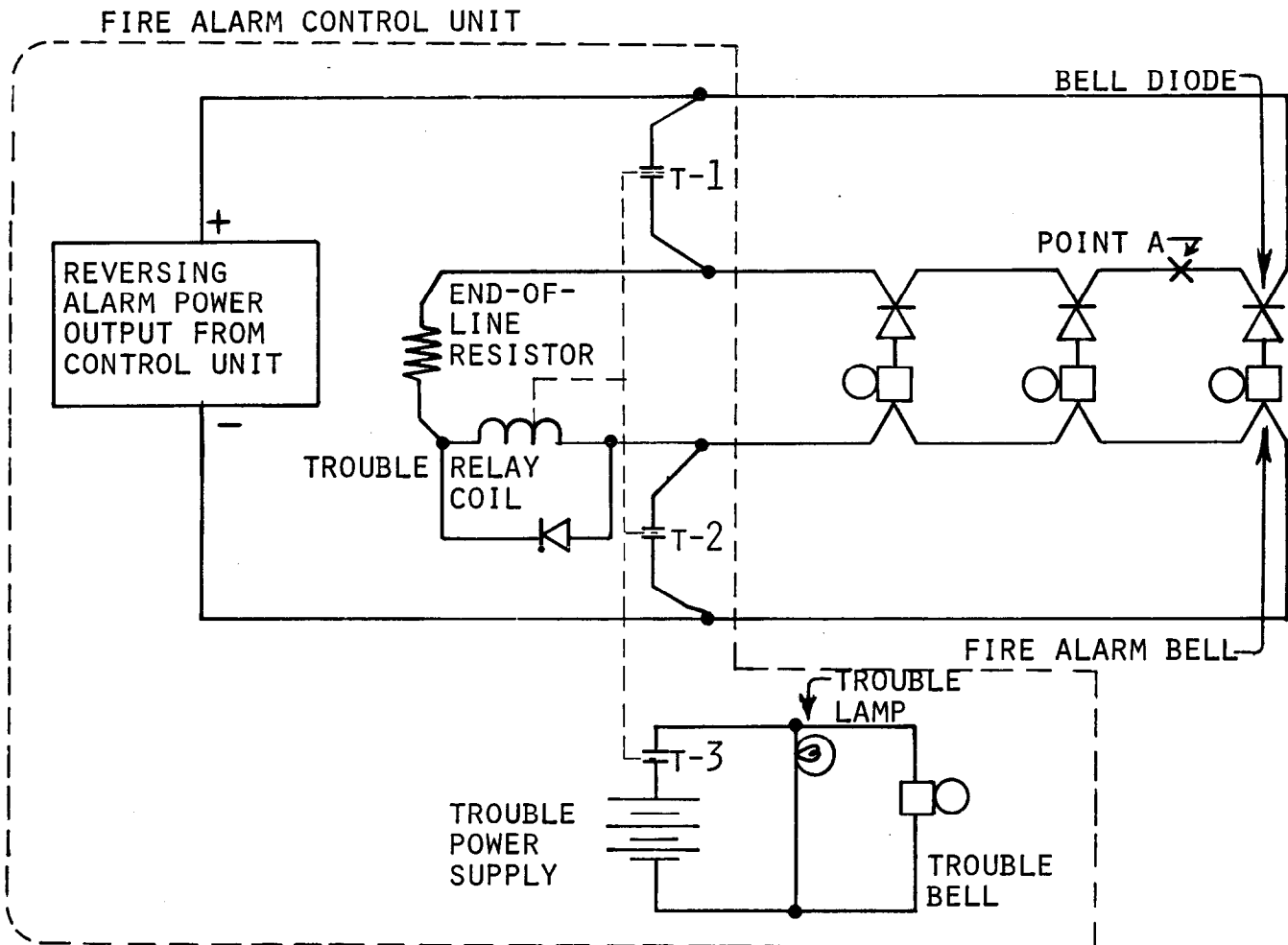
DURING AN OPEN CIRCUIT FAULT, TRANSMITTERS PRODUCE CODED PULSES BY MAKING MOMENTARY CONNECTIONS BETWEEN THE UNGROUNDED "HOT" LOOP AND GROUND,

DURING A GROUND FAULT, TRANSMITTERS PRODUCE CODED PULSES BY MAKING MOMENTARY BREAKS IN THE HOT LOOP CONNECTION TO THE GROUND FAULT,

FIGURE 2-31
CLASS A REMOTE SIGNALING CIRCUIT (McCULLOH)

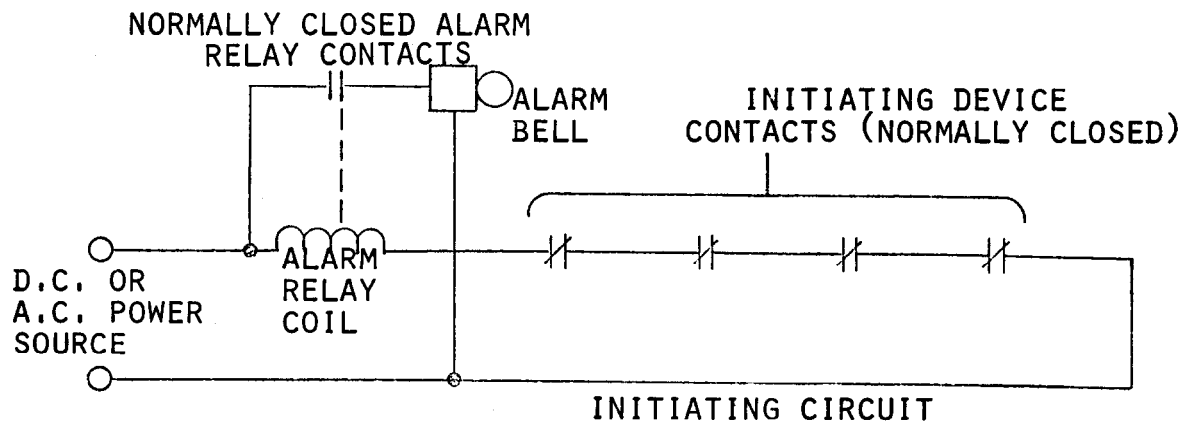
- **Initiating Circuit.** The series normally closed initiating circuit is not recommended or approved by generally accepted listing agencies for fire alarm use. This circuit does not distinguish between circuit trouble and a fire alarm; both conditions cause a fire alarm signal because the opening of normally closed contacts is indistinguishable from opening of the circuit due to a broken wire. Figure 2-33 shows an example of the circuit.

NFPA standards require initiating circuits to be supervised. Many installed initiating circuits are not supervised though first appearances may indicate that they are. To tell if a circuit is supervised, refer to the control unit internal diagrams to see if both ends of any initiating circuit loops are connected to the same point in the control unit, with all switches in their normal positions. If the circuit loops are complete loops with no relay coils, contacts or resistors in them, the circuit is unsupervised, as shown in Figure 2-34. Another unsupervised initiating circuit, which seldom occurs, has two parallel wires with normally open initiating devices connected between them. The wires end at the last initiating device with no end of line resistor, diode or relay.



NOTE: POLARITY AND CONTACTS ARE SHOWN IN THE NORMAL OPERATING CONDITION, A BREAK IN THE WIRING AT POINT A CAUSES ONE SIDE OF THE BELL CIRCUIT TO BECOME ISOLATED FROM THE END-OF-LINE RESISTOR. A TROUBLE SIGNAL RESULTS WHEN THE TROUBLE RELAY DE-ENERGIZES ALLOWING T-3 TO CLOSE. CONTACTS T-1 AND T-2 ALSO CLOSE, CONDITIONING THE CIRCUIT SO THAT AN ALARM CONDITION) REVERSING THE ALARM POWER OUTPUT FORM THE CONTROL UNIT, CAUSES RINGING OF THE BELLS.

FIGURE 2-32
CLASS ALARM INDICATING CIRCUIT



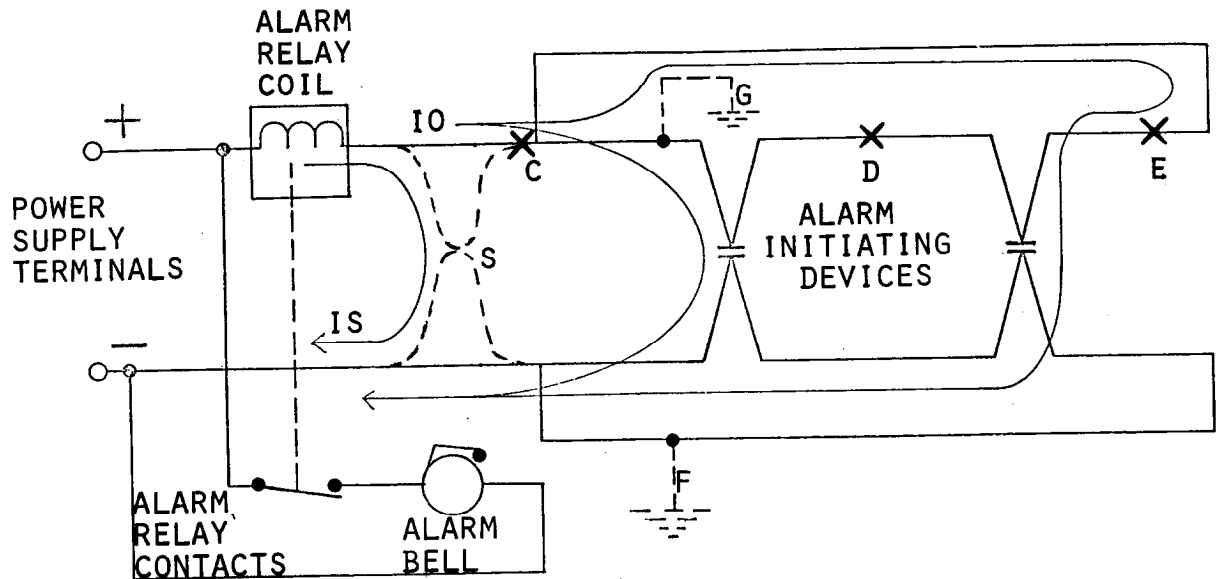
NOTE : WHEN ALARM SYSTEM IS OPERATING, ALARM RELAY IS ENERGIZED, HOLDING ALARM RELAY CONTACTS OPEN. OPENING ANY INITIATING DEVICE CONTACTS CAUSES ALARM RELAY TO REENERGIZE, CLOSING ALARM RELAY CONTACTS AND RINGING THE BELL.

FIGURE 2-33
SERIES NORMALLY CLOSED INITIATING CIRCUIT

- **Indicating Circuit.** A series indicating or bell circuit is generally used with an AC powered control unit. AC powered, series connected audible appliances are usually wired similar to the circuit shown in Figure 2-35. The individual bells are rated at some fraction of the supply voltage, depending on the number of bells. For instance, five bells rated at 24 VAC or ten rated at 12 VAC might be used with a 120-VAC power source. A current limiting resistor at the fire alarm control panel protects the bells and wiring from excessive current, and its resistance and power rating are chosen to compensate for the number of bells actually used. Sometimes the current limiting resistor is combined with a thermostatic device for opening the bell supply circuit when the current has been excessive for a period of time, or the bells have just been operating for some period of time. Such a thermostatic device requires manual resetting to restore the bells to service.

Accepted standards require most indicating circuits to be supervised though many installed alarm systems have unsupervised indicating circuits. The unsupervised circuit may be formed of two complete wire loops with indicating devices connected between the two loops. This circuit can usually be identified by the fact that each indicating (bell) circuit terminal has two wires connected to it. When removed from the terminal, the two wires will show low resistance between them when checked with an ohmmeter.

A constant small supervisory current is supplied to the bell circuit, which energizes the supervisory relay and holds contacts in the trouble circuit open. If a break occurs in the bell circuit, the supervisory relay deenergizes, closing the contacts in the trouble circuit and sounding the trouble bell. In an alarm condition, the alarm relay contacts short circuit the supervisory relay coil, reducing circuit resistance and increasing bell current enough to cause the bells to ring.



- C, D AND E - OPEN FAULTS
- F AND G - GROUND FAULTS
- S - SHORT CIRCUIT FAULT
- IS - SHORT CIRCUIT CURRENT
- IO - POSSIBLE ALARM CURRENT PATHS FOR OPEN CIRCUIT AT D

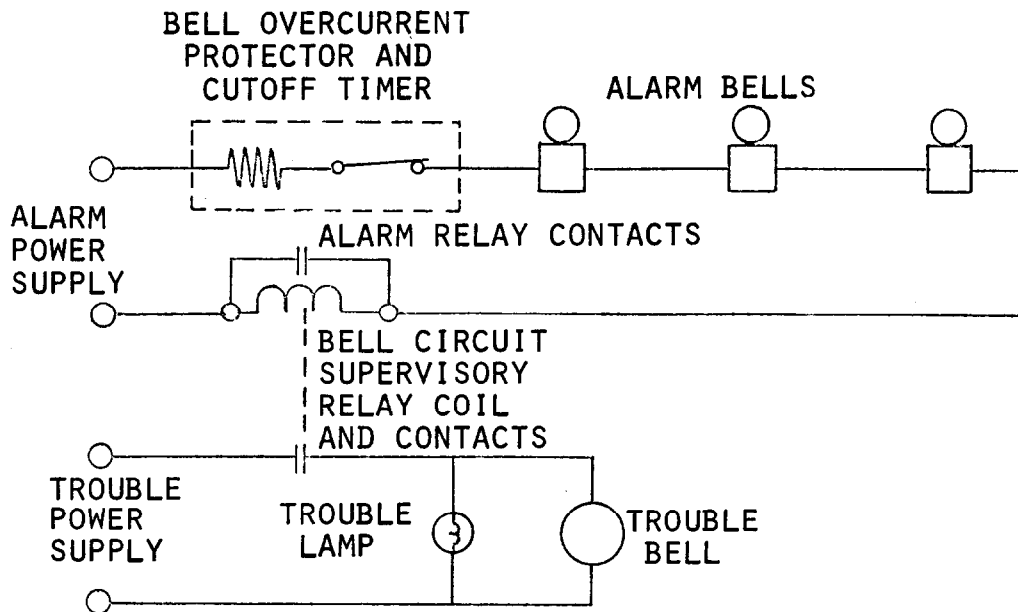
NOTES: CIRCUIT BREAK AT C PREVENTS ALARM CURRENT FLOW FOR ACTIVATION OF EITHER ALARM INITIATING DEVICE, DEACTIVATING THE ALARM SYSTEM WITHOUT ANY TROUBLE INDICATION.

SIMULTANEOUS CIRCUIT BREAKS AT D AND E DEACTIVATE THE INITIATING DEVICE BETWEEN THE BREAKS.

SIMULTANEOUS GROUNDS AT F AND G, OR WIRES TOUCHING AT S ARE A SHORT CIRCUIT AND CAUSE A FALSE ALARM.

FIGURE 2-34
EXAMPLE OF AN UNSUPERVISED INITIATING CIRCUIT

2.4.1.4 Unsupervised Circuits. A fault in an unsupervised circuit causes no trouble signal or automatic conditioning for continued operation. Circuits not required to be supervised include trouble signal sounding circuits, sounding circuits for an audible device in the same room with a control unit (if protected with conduit), and annunciation circuits. Other circuits are required by NFPA standards to be supervised. The other unsupervised indicating circuit sometimes found has two parallel wires with the indicating devices (bells, etc.) connected between them. The wires end at the last indicating device with no end of line device connected. Another clue to an unsupervised indicating circuit is the absence of polarizing features (diodes) on the indicating devices. Two or more circuits of this type may connect to the bell terminals of a control unit.



NOTE: ALARM RELAY COIL AND INITIATING CIRCUITS ARE NOT SHOWN. SEE SECTION 2,4,1,3 IN TEXT FOR FURTHER DESCRIPTION.

FIGURE 2-35
SERIES INDICATING CIRCUIT

2.4.1.5 Power Supervision Applications. Power supplies for fire alarm operation are supervised in a variety of ways. Most frequently the power supervisory devices are contained in the fire alarm control panel.

- Automatic Transfer with Indication. Failure of AC power to the alarm system causes a relay to deenergize. The relay contacts usually cause automatic transfer of power to a secondary source, such as batteries. Additional relay contacts operate audible and visual trouble signals, indicating the need to correct the condition before the secondary source is depleted.
- Indication Only. An example of power supervision is shown in Figure 2-36. In this case, the presence of DC power for the smoke detector is sensed by an end-of-line relay. The relay contacts are connected so that loss of power at the end of the smoke detector power circuit will cause an "open" in the initiating circuit. As discussed for Class A and Class B circuits, this will produce audible and visual trouble signals at the fire alarm control panel. In this case, these signals indicate the need for restoration of smoke detector power. The original failure could have been caused by battery problems or a broken wire in the smoke detector power circuit.

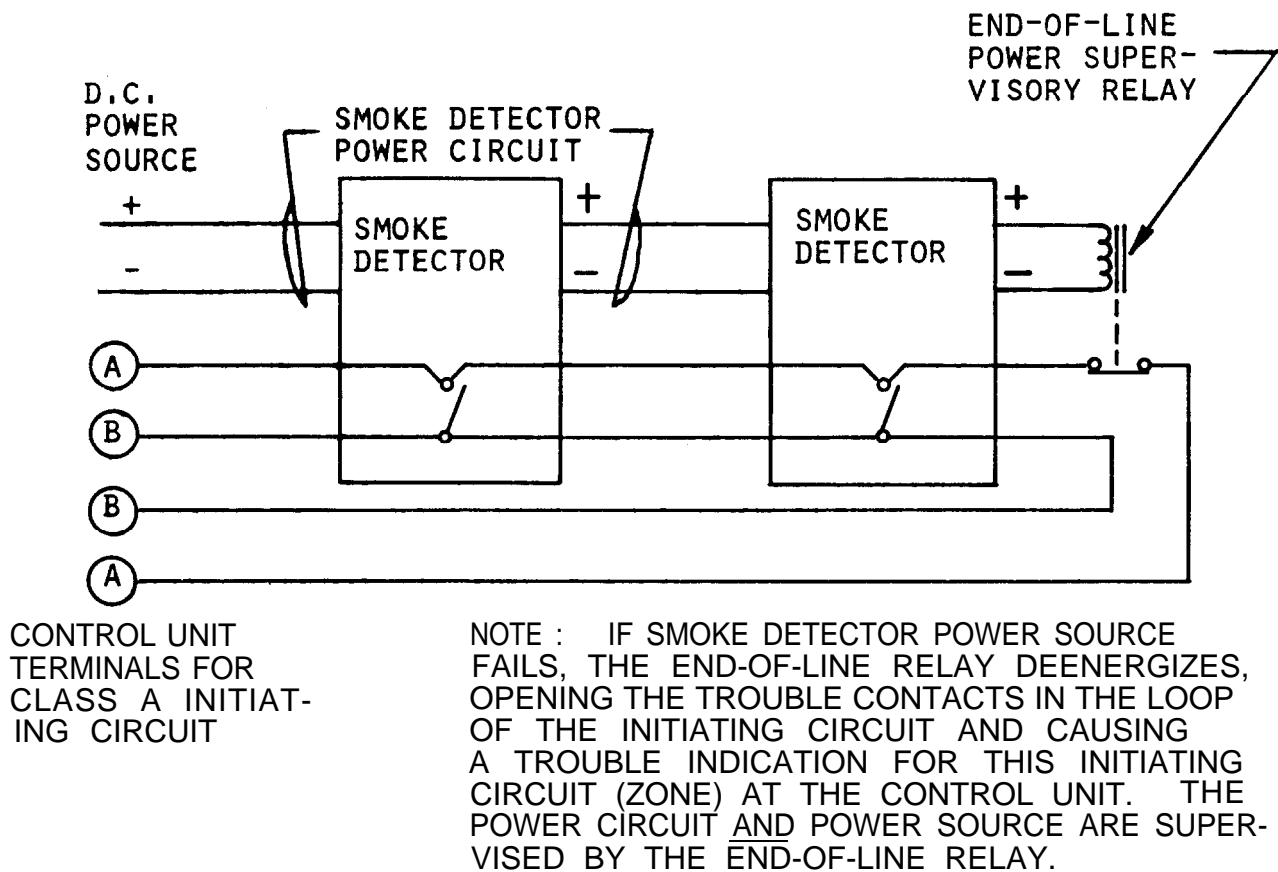


FIGURE 2-36
EXAMPLE OF POWER SUPERVISION

CHAPTER 2. SELF-STUDY QUESTIONS

Instructions: Select the correct answer(s) for each of the following questions.

Q2-1 The primary purpose of a building alarm system is to:

- a. Interrupt normal activities.
- b. Close fire doors and shutdown fans.
- c. Protect life, property and continuity of operations.
- d. Provide a convenient method for having fire drills.

Q2-2 A building alarm system provides audible and/or visual fire alarm signals in response to:

- a. Closing a sprinkler system control valve two turns or more.
- b. Unplugging a smoke detector from its socket.
- c. Operation of a water level switch in a water reservoir.
- d. Automatic operation of heat detectors, smoke detectors or sprinkler waterflow switches.

Q2-3 A noncoded building alarm system:

- a. Cannot identify the location of the device causing the alarm.
- b. May identify the source of the alarm by the use of annunciation.
- c. May cause bells to ring in a distinctive pattern identifying the source of the alarm.
- d. May cause the audible signals to sound in a march-time cadence to expedite evacuation.

Q2-4 A multiplex alarm system is considered to be:

- a. Coded.
- b. Noncoded.
- c. Old fashioned.
- d. Undesirable because it is not an approved installation.

Q2-5 Paper tape recorders are often used with:

- a. Noncoded systems.
- b. Small fire alarm systems.
- c. The fan shutdown feature.
- d. Coded systems.

Q2-6 The trend in operating voltage for modern control unit circuitry, initiating circuits, and indicating circuits is toward:

- a. Low voltage AC.
- b. High voltage AC.
- c. Low voltage DC.
- d. High voltage DC.

- Q2-7 A building fire alarm control unit typically does not contain:
- Relays.
 - Initiating devices.
 - Terminals.
 - A power supply.
- Q2-8 A drill switch in the control unit:
- Sounds the fire alarm audible signals.
 - Causes transmission of an alarm to base alarm headquarters.
 - Causes the building fans to shutdown.
 - Causes fire doors to close.
- Q2-9 Alarm initiating devices, such as the following, initiate the electrical sequences which result in a fire alarm:
- Bells and horns.
 - Flashing lights and sirens.
 - Heat and smoke detectors.
 - Chimes and buzzers.
- Q2-10 The coding contacts in a shunt noninterfering building system initiating circuit are:
- Normally open in a series circuit.
 - Normally closed in a series circuit.
 - Normally open in a parallel circuit.
 - Normally closed in a parallel circuit.
- Q2-11 A trouble condition is usually annunciated using a:
- Flashing light.
 - Red or pink light.
 - Blue or green light.
 - Yellow or amber light.
- Q2-12 In a presignal alarm system, when an alarm occurs:
- All general alarm signals sound immediately.
 - No audible signals sound.
 - Some audible signals sound immediately and general alarm signals may be activated by an authorized person.
 - Alarm signals are only transmitted to base alarm headquarters.
- Q2-13 A building alarm system power supply does not:
- Convert the AC line voltage to low voltage AC.
 - Rectify low voltage AC to produce low voltage DC.
 - Charge the system standby battery.
 - Directly power the building fans.

- Q2-14 The following function is almost never controlled by the building fire alarm system:
- a. Fire door closure.
 - b. Shutting down refrigerant compressors.
 - c. Fan shutdown.
 - d. Release of fire extinguishing agent.
- Q2-15 Automatic fire alarm initiating devices do not detect:
- a. Barometric pressure.
 - b. Heat.
 - c. Infrared radiation.
 - d. Smoke.
- Q2-16 Detection of waterflow in a building automatic sprinkler system:
- a. Mainly provides for building evacuation.
 - b. Always causes a sprinkler supervisory signal.
 - c. Is intended to summon aid in fighting the fire.
 - d. Indicates that at least two sprinklers are operating.
- Q2-17 Sprinkler supervisory alarm:
- a. Initiating circuits never use an end-of-line resistor.
 - b. Initiating circuits are never normally closed loop circuits.
 - c. Indicating devices are entirely different from fire alarm indicating devices.
 - d. Systems continuously check the readiness of automatic sprinkler systems,
- Q2-18 Building alarm systems sometimes are connected to a remote signal receiving station because:
- a. It is desirable to inform trained personnel who are competent to take necessary action.
 - b. The occupants of the building may be excited.
 - c. The building may not be occupied at the time of the fire.
 - d. All of the above.
- Q2-19 A remote station type base alarm system:
- a. Is normally a coded system.
 - b. Requires a pair of wires for each alarm signal.
 - c. Provides signaling from municipal type transmitters.
 - d. Does not use annunciation.
- Q2-20 Central station type alarm systems:
- a. Are widely used commercially for 24-hour alarm monitoring.
 - b. Require a separate pair of wires for each transmitter.
 - c. Are noncoded systems.
 - d. May have up to 1,000 transmitters on a single circuit.

Q2-21 One of the distinctive features of a radio call box system:

- a. Is the location of alarm transmitters.
- b. Is the fact that it is a noncoded system.
- c. Is the requirement for complete duplicate receivers.
- d. Is the fact that a building alarm system can be connected to actuate an alarm transmitter.

Q2-22 A multiplex base alarm system:

- a. Is noncoded.
- b. Is similar to a remote station system in the connection of building systems to the base system.
- c. Uses one circuit or communication channel for many signals.
- d. Is always a proprietary system.

Q2-23 Automatic dialer type base systems:

- a. Require wiring from the building systems that is exclusively for alarm use.
- b. May be the tape recorded message type or the digital coded message type.
- c. Never have a printer at the receiver.
- d. Require a building occupant to dial the number of the receiving equipment, like a telephone call.

Q2-24 The following is not a transmitter that can be used in a base alarm system:

- a. A McCulloch coding mechanism.
- b. A march-time coding mechanism.
- c. A reversal signal relay.
- d. A digital dialer.

Q2-25 In a radio call box system:

- a. The test signal may include a low battery or other trouble signal.
- b. The receiving equipment includes a radio receiver and a signal processor.
- c. A test signal is transmitted automatically each day from each transmitter.
- d. All of the above.

Q2-26 Multiplex base alarm system receiving installations:

- a. Have annunciation and alpha-numeric displays.
- b. Must have duplicate sets of receivers.
- c. Receive daily test signals from every transmitter.
- d. Only seldom are in contact with the individual building alarm systems.

- Q2-27 Remote station receiver installations are usually characterized by:
- a. A complete lack of power supplies.
 - b. A cathode ray tube for display of information.
 - c. A keyboard for entry of new information.
 - d. A receiver module for each transmitter.
- Q2-28 The McCulloh tape register may record an alarm signal identified:
- a. By holes punched in a paper tape.
 - b. By detailed information on a 1/2-inch-wide tape.
 - c. By alpha-numeric symbols on a tape.
 - d. All of the above.
- Q2-29 Power for driving a base alarm system transmitter at a protected building is frequently supplied by:
- a. Line voltage DC.
 - b. A rechargeable battery.
 - c. Both of the above.
 - d. None of the above.
- Q2-30 Generally, the small power supplies for alarm equipment at a protected building are designed to provide:
- a. At least 10 hours of standby operation with AC power off.
 - b. At least 2 hours of standby operation with AC power off.
 - c. At least 15 minutes of standby operation with AC power off.
 - d. At least 4 hours of standby operation with AC power off.
- Q2-31 Base alarm systems may provide the following service(s):
- a. Monitoring of fire alarm signals.
 - b. Monitoring of fire trouble signals.
 - c. Monitoring of open or closed condition of sprinkler valves.
 - d. All of the above.
- Q2-32 The feature in fire alarm systems which warns of potential or actual electrical problems is known as:
- a. Signal monitoring.
 - b. Sprinkler supervision.
 - c. Electrical supervision.
 - d. Trouble.
- Q2-33 A class "A" supervised circuit has the capability to:
- a. Only cause a "trouble" signal, if a fault occurs.
 - b. Cause a false alarm, if a fault occurs.
 - c. Cause a trouble signal and continue operating, if a fault occurs.
 - d. None of the above.

Q2-34 A class "B" alarm initiating circuit has:

- a. A continuous small supervisory current which is too low to energize the trouble or alarm relays.
- b. No end-of-line device.
- c. A continuous small supervisory current which is adequate to energize the trouble relay but not the alarm relay.
- d. None of the above.

Q2-35 Most approved initiating devices:

- a. Have normally closed contacts which open on alarm.
- b. Have normally open contacts which cause a short circuit on alarm.
- c. Have double sets of contacts, one pair for trouble and one pair for alarm.
- d. None of the above.

Q2-36 If an open fault occurs in a supervised circuit, the supervisory current typically:

- a. Drops to zero.
- b. Increases, causing a false alarm.
- c. Remains constant, but the fault causes a trouble signal.
- d. None of the above.

Q2-37 A two wire reversal type remote signaling circuit:

- a. Has the capability to continue operating with an open fault.
- b. Signals an alarm by a reversing voltage but not current.
- c. Signals an alarm by the transmitter causing a short circuit.
- d. Is usually considered to be Class "B."

Q2-38 A class "A" initiating or indicating circuit is typically:

- a. A two-wire circuit.
- b. A four-wire circuit.
- c. A circuit in which a few devices are polarized.
- d. None of the above.

Q2-39 Class "A" remote signaling circuits:

- a. Are most often the reversal signal type.
- b. Are usually not used with coded base alarm systems.
- c. Often make use of earth ground as an electrical conductor.
- d. None of the above.

Q2-40 A series indicating circuit is usually:

- a. Associated with AC-powered indicating devices.
- b. Associated with an AC-powered control unit.
- c. Protected from excessive current by a current limiting resistor.
- d. All of the above.

CHAPTER 3. INSPECTION, TESTING, AND MAINTENANCE OF FIRE ALARM SYSTEMS

3.1 GENERAL MAINTENANCE. General maintenance procedures include periodic testing and troubleshooting, cleaning, repair, and replacement. If possible, it is important to have all manufacturer's literature available for each piece of equipment and component in use.

When a component or device needs to be repaired or replaced, check with the manufacturer's customer service department for repair instructions or packing and shipping instructions. When contacting the manufacturer, be prepared to give all pertinent information available regarding equipment model number, serial number, and the part numbers of any needed replacement parts. For most efficient maintenance and troubleshooting, combine tests with regular inspections. A summary of test frequencies for alarm system equipment is included in Table 3-1. NFPA 72H, "Guide for Testing Procedures for Local, Auxiliary, Remote Station and Proprietary Protection Signaling Systems" (1984) should also be consulted.

When performing tests which cause sounding of audible and/or visual signals, schedule the tests so as not to cause disruption of normal activities unless the tests are coordinated with regular drills. Any tests should be coordinated with the individual in charge of the facility.

3.2 MAINTENANCE REFERENCE MATERIALS. Because of the variations in equipment from manufacturer to manufacturer and the numerous types of circuits and devices in use, it is important to have the following reference materials available to personnel responsible for servicing:

- Wiring and Equipment Schematic Diagrams. Complete, accurate wiring diagrams of each type of device in use, of each circuit as installed, and equipment schematic diagrams.
- Manufacturer's Data Sheets. The descriptive information in manufacturer's data sheets on all equipment in use and manufacturer's instructions for any special testing and maintenance.
- System Revision Information. Information on all extensions or modifications to existing fire alarm systems.
- Tags. Identification of wires removed from terminals during repair or testing to insure accurate reconnection. Improperly connected wires may make a fire alarm device or circuit ineffective or may actually damage equipment.
- Inspection Record Card. Record date of inspection, inspector's name, remarks, etc. for each piece of equipment.

TABLE 3-1
SUMMARY OF INSPECTION AND TEST FREQUENCIES FOR ALARM SYSTEMS

	DAILY	WEEKLY	MONTHLY	QUARTERLY	SEMI- ANNUALLY	ANNUALLY
Visual inspection of all alarm equipment			X *			
Operational test of initiating and signaling circuits for populated buildings			X *			
Operational test of initiating and signaling circuits for unpopulated buildings				X *		
Operational test of manual fire stations, coded and noncoded					X *	
Operational test of sample spot type heat detectors (All detectors tested in 5 year period)					X *	
Operational test of line type heat detectors (Simulated test only of nonreusable type)					X *	
Operational test of smoke detectors (All detectors tested in 5 year period) .					X *	
Operational test of IR flame detectors					X	
Optical integrity test of UV flame detectors if test feature is built in			X			
Operational test of UV flame detectors					X	
Operational test of waterflow detectors				X		
Operational test of supervisory initiating devices						X
Operational test of indicating devices			X			
Operational test of base system circuits			X			
Operational test of base system Class A circuits with ground and open faults				X		
Operational test of base system transmitters				X		
Operational test of major receiving equipment	X					
Operational test of noncoded receiver modules				X		
Operational test of signal recording devices	X					
Operational test of engine driven emergency generators		X *				
Check rechargeable battery water level		X				
Check rechargeable cell voltages			X *			

* Frequency may be extended to annually where the system is supervised.

3.3 MAINTENANCE OF COMMON COMPONENTS. In general, detectors are returned to the manufacturer as a complete package for repair. However, control units and annunciators are large and interconnected with a number of other system components. There should be some attempt at local repair before shipping the total unit to the manufacturer. Some components are used in many types of equipment, including fire detectors, control units, and annunciation units. The following types of components can be replaced, adjusted, or repaired: Relays, Resistors, Capacitors, Diodes, Transformers, Fuses/Circuit Breakers, Control Panel Switches, Motors, Lamps/Visual Indicators, Wiring, Meters.

3.3.1 Relays. There is no routine maintenance required for relays; maintenance should be in response to a symptom or suspected malfunction. Relay adjustment is a specialized skill and requires some special tools and instruments. The safest relay maintenance is direct replacement with an identical relay. Keep a spare relay of each type on hand and return any relays with known defects to the equipment manufacturer for reconditioning. Relay contact cleaning requires a contact burnishing tool. Clean contacts carefully to avoid removing precious metal plating on the contact surface. Move the burnishing tool against the contact surfaces in the direction of the normal wiping action of the contacts.

Relay tests may help determine if the relay is the source of the problem. Measuring coil resistance with an ohmmeter will tell if there is a broken wire to the coil or a burned out coil (no continuity, infinite resistance). Normal coil resistance varies from about 50 ohms for heavier duty relays to about 20,000 ohms for very sensitive relays. Some relays are constructed so the defective coil can be removed and replaced with a new coil. The type or catalog number of the relay should indicate the coil resistance so the proper replacement can be obtained from the equipment manufacturer.

Replacing a coil usually involves removing the relay cover, removing one or more screws to remove the old coil, unsoldering coil connections, and mechanically removing the coil. Installing the new coil is the reverse. Readjustment of the relay operating points to the equipment manufacturer's specifications is usually necessary because of the mechanical disassembly and reassembly required and the possible minor change in coil resistance.

An ohmmeter check for continuity between the relay frame and either coil terminal, using a sensitive resistance scale ($\times 10,000$ or higher), is a partial check to tell if insulation between the relay coil and the relay frame has broken down. A reading of continuity (any reading other than infinity) indicates an abnormal condition. Reinsulate any spot that shows signs of arcing between the coil and the frame and recheck for continuity. The ohmmeter check does not simulate operating conditions and should be considered only a partial check. The ohmmeter may indicate no insulation breakdown when there is a definite breakdown at the higher voltages reached during alarm system operation.

A continuity check of relay contacts can indicate if contacts transfer when the relay is alternately energized and deenergized. The ohmmeter should be connected to the common terminal of the relay contacts (usually marked C) and the normally closed terminal (usually marked NC) with the relay deenergized. The resistance measured should be very nearly zero or a fraction of an ohm maximum, on a $\times 1$ resistance scale. Also with the relay deenergized, the resistance measured between common and normally open (usually marked NO) should be infinite,

If the contact resistance also can be measured with the relay energized (normal coil voltage applied), the above readings should be reversed, i.e., common to normally closed should be infinite and common to normally open should be zero or a fraction of an ohm, maximum. If you do not get proper readings, inspect the contacts for dirt, corrosion, or other causes of poor contact. Obvious contamination can be removed by inserting a piece of thin cardboard or heavy paper between the contacts, pressing the contacts together, and pulling the cardboard or paper out. Recheck contact resistance. If the cleaning was unsuccessful, repeat the process or send the relay to the equipment manufacturer for reconditioning. Contacts may also be cleaned with a burnishing tool, but this must be done carefully to avoid removing the precious metal plating used on some contacts. Adjusting contact pressure requires a sensitive contact pressure gauge and special blade bending tools, or smaller wrenches or screwdrivers. Do not try to adjust contact pressure without some training. Also, be sure to have the equipment manufacturer's relay specifications. Contact pressure should never be less than about 6 grams, measured with a contact pressure gauge.

Sealed relays cannot be cleaned, adjusted, and repaired, although continuity checks can be made to see if there is a defect in the relay that requires returning the relay to the equipment manufacturer for repair.

3.3.2 Resistors. No periodic maintenance is required for resistors. When a problem arises, a visual inspection for physical damage may tell if a resistor is defective. Examples of physical damage are cracked and discolored resistor bodies, broken connections to circuit terminals, and broken resistor wires on adjustable wirewound resistors. Cracked resistors and broken connections can be caused by physical blows. Discoloration along with cracking of a resistor body may be caused by excessive current through the resistor and the resulting heat. Overheating a carbon resistor changes its resistance value permanently. Depending on the precision required in the application, it may be necessary to replace the resistor.

Wirewound resistors are frequently still functional after physical or electrical abuse. However, adjustable wirewound resistors with a broken resistance wire in the area where wire segments are exposed for contact with the adjustable sliding band will not function properly. The exposed wires may be broken when attempting to adjust the resistance without relaxing the contact pressure of the sliding band first. These wires will not accept conventional solder at normal soldering temperatures; the resistor should be replaced. Also, adjustable resistors do not operate properly if the sliding band is not tightened firmly after final adjustment.

Open construction rheostats and potentiometers can oxidize or accumulate dust on contact surfaces. For positive electrical contact, keep contact areas clean. Clean only if there is a problem due to poor contact of the contact arm. Frequently, moving the contact arm back and forth across the supposed poor contact area should restore good electrical contact. If this does not work, apply a mild solvent, such as alcohol or trichloroethylene, with a clean cloth and move contact arm back and forth. When cleaning, first note the original adjustment so that it can later be reestablished. Disconnect power before cleaning to avoid electrical shock or possible burns.

3.3.3 Capacitors. Electrolytic capacitors are often used in the power supply section of low voltage DC control units and electronic smoke and fire detectors. They have a limited life and their failure can account for

inadequate voltage quality to electronic fire detectors from the main alarm system power supply. Other capacitor problems depend on the type of system. Capacitors are available in a wide range of quality. Low voltage quality and high temperature are causes of shortened capacitor life. Some capacitor tests can be made with an ohmmeter, a DC voltmeter, or an ammeter in series with a battery or other DC voltage source (Figure 3-1). It is only necessary to disconnect one end of the capacitor from its circuit to test it.

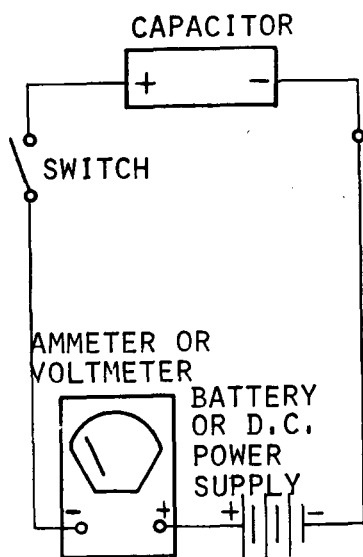
All the capacitors normally found in an alarm system can be tested the same way, but the results are more reliable and easier to interpret with larger values of capacitance. When testing electrolytic capacitors, be sure that the test arrangement applies voltage to the test capacitor with the polarity indicated on the capacitor; for nonpolarized capacitors, polarity is not important. If an ohmmeter, or a resistance scale of a multimeter is used, the terminal marked "+" or "positive" on the test meter may actually be negative on the resistance ranges. Check the meter output polarity with a second meter, using a voltmeter range on the second meter. Once polarity has been determined, the test consists of connecting the ohmmeter, or combination of DC source with voltmeter or ammeter across the capacitor terminals while watching the meter indicating needle deflect. For a good capacitor, the needle will deflect and return to its original position. Larger values of capacitance cause the needle to return slower.

Open capacitors (those with an internal broken or loose connection) cause no deflection of the needle. To distinguish open capacitors from small value capacitors, it may be necessary to use the x10,000 ohms resistance scale (use a low voltage scale, 2.5 volts or a low current scale, 1 milliampere or less, on the alternate test arrangement).

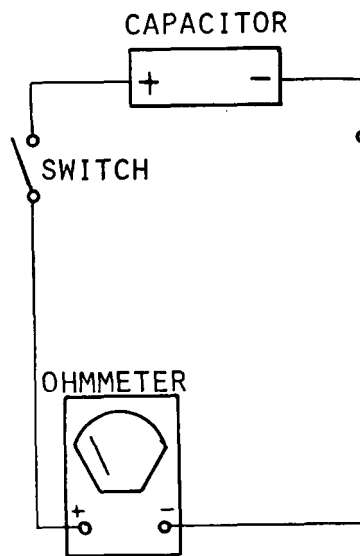
Leaky capacitors (those which have a partial short internally) cause the needle to not return fully to the original reading. Some leaky electrolytic capacitors can be "formed". The leakage current can be gradually reduced to an acceptable value by applying approximately the capacitor's rated DC voltage in the proper polarity. The diagram of Figure 3-1 can be used for forming, using a DC source approximately equal to the capacitor's rated voltage and the meter set to a sensitive current scale. As the capacitor forms and leakage current reduces, it may be necessary to switch to a microampere scale to see any further decrease in leakage current. When leakage has been reduced to approximately 1 microampere or less, the capacitor is formed and useable. Replacement capacitors which have been unpowered for a long time may need to be formed. In equipment, electrolytic capacitors form by applying normal equipment power for a warmup period of about 1/2 hour.

3.3.4 Diodes. Diodes are solid state devices used chiefly as rectifiers, converting alternating current (AC) to direct current (DC). Diodes are used in alarm system power supplies and for charging circuits for batteries. A typical charging circuit which uses a diode bridge or full wave bridge is shown in Figure 3-2.

To test or check the diodes in such a circuit, disconnect the AC power and at least one side of the battery. If possible, disconnect the diodes from the circuit to check them individually. Make continuity checks with an ohmmeter (or a resistance scale of a multimeter) or with a DC voltmeter in series with a DC power source. Good diodes allow current flow in one direction and not in



A. CAPACITOR TEST WITH AMMETER OR VOLTMMETER AND D.C. SOURCE



B. CAPACITOR TEST WITH OHMMETER (WITH INTERNAL D.C. SOURCE)

NOTES: WITH ELECTROLYTIC OR POLARIZED CAPACITORS THE POLARITY OF THE TEST SET-UP IS IMPORTANT FOR A GOOD TEST (POLARITY IS NOT IMPORTANT FOR NONPOLARIZED CAPACITORS), THERE MAY BE NO POLARITY MARKINGS ON AN OHMMETER AND THE + AND - MARKINGS AT THE TEST WIRE SOCKETS OF A MULTIMETER MAY REFER ONLY TO VOLTAGE AND CURRENT RANGES, YOU MUST DETERMINE THE OUTPUT POLARITY OF THE TEST OHMMETER FOR A GOOD TEST AND MAKE THE CONNECTIONS INDICATED.

THE SWITCH SHOWN ONLY INDICATES THE NEED FOR A SUDDEN CONNECTION OF THE CAPACITOR TO THE TEST CIRCUIT WHILE THE TESTER WATCHES THE METER NEEDLE,

FIGURE 3-1
CAPACITOR CHECKING METHOD

the other. Thus a check of individual diodes will show low resistance in one direction and infinite resistance in the other direction when checked with an ohmmeter. Use a low resistance scale (x1, x10, or x100) for checking the low resistance and a high resistance scale (x10,000 or x100,000) for checking the high resistance direction. In addition to checking a diode's forward and reverse resistance, compare the diode with others of its type, using the same meter and scale settings. Bad diodes can show infinite resistance in both directions (open diode) or low resistance in both directions (shorted diode). Occasionally a diode will exhibit characteristics which may appear normal, but which are quite different from others of its type. Bad diodes and diodes with nonstandard characteristics should be replaced.

Diodes in a diode bridge may be packaged so disassembly is impractical. In this case, in the circuit of Figure 3-2, disconnect one side of the transformer secondary winding to eliminate the resistance of the transformer winding shunting the diode bridge and disconnect one end of capacitor F. The capacitor may be leaky or polarized so as to affect readings, since diode checks are made with voltage of both polarities.

Checking continuity from B to D with B connected to the positive terminal of the test arrangement shows infinite resistance if all diodes are good. If some continuity does exist (measurable resistance less than infinity), it can be caused by at least two shorted diodes in the diode bridge, both on the same side (right or left in the diagram). See the table in Figure 3-2 for proper resistance readings while checking resistance between pairs of points in the diode bridge. In general, low readings where infinity readings are shown in the table indicate that there are one or more shorted diodes in the bridge. High or infinite readings where low readings are shown in the table indicate that there are one or more open diodes in the bridge. When a diode bridge cannot be disassembled and one or more diodes are defective, replace the bridge.

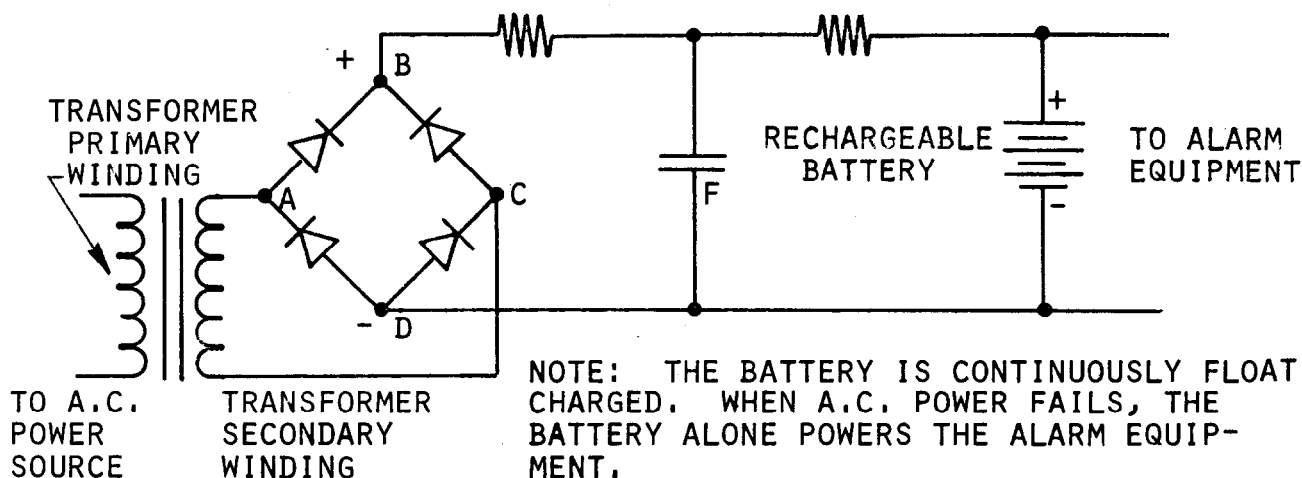
3.3.5 Transformers. The power supply of low voltage fire alarm control units contains a stepdown transformer to convert the incoming line voltage to a lower AC voltage (usually 24 or 12 VAC). A typical power supply schematic diagram is shown in Figure 2-9. Line voltage control units also frequently contain a stepdown transformer so lower voltage rated internal components and external sounding devices can be used.

Visual inspection for discoloration of insulation caused by overloading and consequent overheating of the transformer is the only routine maintenance appropriate for the transformer. When operated within their rated power range, transformers should be cool enough to allow you to rest your hand on the transformer. If the transformer is too hot or there are other signs of equipment malfunction, check for voltage, current, short circuits, and foreign grounds on the circuit wiring and for short circuits or defective components in the control unit. Look at the control unit manufacturer's schematic diagrams and servicing instructions to do this properly.

The transformer may have no AC output voltage with normal input voltage applied and stay cool. This normally means the transformer has already been burned out. Make voltage measurements at the transformer terminals with no intervening fuses or other components which, if defective, could affect the meter readings. Discolored transformer insulation, burned out fuses, short circuits, and/or other defective components in the control unit are signs that the transformer is burned out.

A frequent result of a transformer burning out is an open primary winding of the transformer. During a heavy current demand, the primary winding of the transformer increases in temperature, causing the wire to melt and separate, stopping the flow of current and opening the primary circuit. Wire can also melt in the secondary winding, but in a stepdown transformer, the secondary winding is made of heavier gauge wire to better dissipate excess heat. Normal ohmmeter readings for a stepdown transformer might be several hundred ohms for the primary (high voltage) winding and a few tens of ohms for the secondary (low voltage) winding. There should be no continuity (infinite resistance) between either primary terminal and either secondary terminal.

After the transformer is removed from the circuit, it can be checked with an ohmmeter. A burned out or short circuited transformer should be replaced. Contact the manufacturer of the control unit for the replacement transformer so that the mounting and connecting provisions, and voltage and wattage ratings, will be proper.



(A) BASIC POWER SUPPLY CIRCUIT WITH STANDBY BATTERY

	A+	B+	C+	D+
A-	NOT CHECKED	∞	∞	L
B-	L	NOT CHECKED	L	L
C-	∞	∞	NOT CHECKED	L
D-	∞	∞	∞	NOT CHECKED

L LOW RESISTANCE

∞ INFINITE RESISTANCE

NOT CHECKED

+ - INDICATE OHMMETER OUTPUT POLARITY

NOTE: A COMPLETE RESISTANCE CHECK OF A DIODE BRIDGE REQUIRES ALL THE MEASUREMENTS INDICATED. CONTINUITY IS CHECKED BETWEEN EACH OF THE FOUR TEST POINTS AND EACH OF THE OTHERS WITH BOTH POLARITIES OF THE OHMMETER.

(B) FULL WAVE DIODE BRIDGE RESISTANCE CHECKS

FIGURE 3-2
DIODE BRIDGE CHARGING CIRCUIT AND RESISTANCE CHECKING METHOD

3.3.6 Fuses/Circuit Breakers. Fuses and circuit breakers require no routine maintenance in a properly designed and installed alarm system. When abnormal conditions cause a loss in power to equipment, or when problems involve the power source, check the fuses, fuse holders, and/or circuit breakers and their termination points. Power problems are indicated when pilot lights are out and audible devices do not sound during tests. First check the continuity of fuses and the tripped/untripped indicator on circuit breakers. Whether status is visually indicated or not, circuit breakers can be reset by operating them to the off position and back on. Keep a supply of spare fuses of each current rating and type on hand.

3.3.6.1 Fuses. Use a table for cross referencing to other manufacturer's equivalent types for fuse replacement if the exact manufacturer's type cannot be matched. Repeated blowing of fuses indicates a problem exists which should be corrected. DO NOT REPLACE A FUSE WITH A HIGHER CURRENT RATING FUSE, EVEN AS A TEMPORARY MEASURE. Damage to other components, excessive heating and, possibly, fire can result.

Fuse bodies may be glass, fiber, or ceramic. The fuse element melts when overloaded with excessive current. The fuse element can be checked visually with glass fuses, but fuses that have a nontransparent body must be checked for continuity with an ohmmeter or by putting in a replacement fuse. For fuses showing no continuity (having infinite resistance), replace them with fuses with the same physical dimensions, current rating, and speed of burn-out. Slow-blow fuses can be used when a few seconds of high current, perhaps double the normal current or greater, will not damage the protected equipment. Normal speed fuses burn out in an hour or less with a current overload of 35%. Depending on the exact type, fast-acting fuses burn out in 1 second or a fraction of a second with slight current overloads. Fast-acting fuses are used to protect solid state equipment which cannot tolerate even short duration excessive current without damage to components.

To check tubular fuses mounted in spring clips, use a proper size fuse puller to remove and reinsert the fuse. Other tools (such as a screwdriver) can cause electrical shock, injury, or electrical and physical damage to the equipment. With the fuse puller, check the spring clip tension by pulling straight out on the fuse near each end to see if the fuse is held firmly by its holder. A loose fitting fuse holder can result in heating of the fuse due to the resistance created by the poor connection. The added heating can cause the fuse to blow at a lower current than its rating. If the spring clip is not holding the fuse firmly, turn off power at the main disconnect, remove the fuse, and bend the fuse holder sides inward slightly with pliers until the clip holds the fuse firmly. Fuses should be pulled annually to verify the rating of the fuse.

3.3.6.2 Circuit Breakers. Most circuit breakers are enclosed modular assemblies and spare parts are generally difficult to obtain. If defective, it is usually simpler to replace the entire circuit breaker as a unit. A defective circuit breaker usually fails in the safe direction. It opens the power circuit at a lower current than its rating rather than a higher current. If a circuit breaker requires frequent resetting and no circuit fault can be found to account for the problem, measure the current flow through the circuit breaker under the conditions which cause the circuit breaker to actuate. If this current is well below the rating of the circuit breaker, the circuit breaker is defective and should be replaced.

Good wiring connections at terminals for fuse holders and circuit breakers are very important. These connections carry larger currents than other termination points. Poor connections can result in discharged or damaged batteries and intermittent operation of the equipment. Screw type connections should be snug, but not so tight to cut into the wire to the point of weakening the wire. Be careful when disconnecting and reconnecting wires. Do not cut into the conductor when stripping off insulation, especially with the smaller wire sizes. If terminal screws have been overtightened and cut into a conductor, cut off the damaged end and carefully strip the insulation from the new end with wire strippers adjusted to the wire size being used. Form the new end to fit the terminal screw with a pair of long-nosed pliers.

3.3.7 Control Panel Switches. Control panel switches are permanent assemblies, not intended to be repaired or maintained. During routine testing, operate all switches to wipe off contact oxidation and test for proper function. Make arrangements with building personnel and the fire department, if necessary, before operating the bell test, drill, and fire department disconnect switches. If a switch does not function properly, replace it with an equivalent switch. Take special care when replacing low voltage, low current DC switches to be sure that the replacement switch is rated for dry circuit application.

3.3.8 Motors. Motors are used in alarm equipment to drive coding devices, paper tape recorder mechanisms, some types of audible appliances, and as timing devices in the time/date stamp on paper tape alarm recorders. For all motor replacement, check any gears or geartrain driven by the motor for binding, excessive wear, and proper lubrication. In timing applications, clean and reoil gears with watch oil whenever they are accessible for service.

3.3.8.1 Spring Motors. Many older coding devices are the springwound escapement type which have their tripping adjustments factory set. They should not require readjustment. These devices should be sparingly lubricated with watch oil about every 5 years. Clean any rust spots and oil the blue steel clock spring with watch oil at the same time.

Be careful when working on clock springs to avoid personal injury. Run the mechanism until the spring is run down, check any speed governor weights for firm mounting, and tighten set screws for any loose weights. Check mechanism function and restore it to its normal position before final winding of the spring. In case of mechanical damage to an escapement mechanism, return the mechanism, carefully packaged, to the manufacturer for repair and adjustment.

3.3.8.2 DC Motors. More recently manufactured coding devices and paper tape recorders are frequently driven with small permanent magnet DC motors. If the motor does not operate or its speed is erratic and measurement with a voltmeter at the motor terminals indicates that stable voltage is being supplied to the motor, usually the motor brushes must be replaced.

The following describes brush replacement for one motor type frequently used in alarm equipment.

- Obtain the necessary tools for brush replacement--a pair of nonmagnetic tweezers (stainless steel, brass, etc.) and a jewelers screwdriver.
- Remove the plastic or thin sheet metal cover which protects the brush holder and commutator assembly by unscrewing the small cover screws. The cover may also be stuck in place with varnish or other sealant. Use the screwdriver to break the cover loose from the motor housing.
- Remove the brushes. They are about the size of a short piece of pencil lead. Handle them with tweezers. The two brush holders are dielectric tubes, slotted at the outer end to allow the (straight spring wire) contact springs to hold the brushes in place. Lift the springs gently, only enough to move them out of their slots, and shake the old brushes out of the holder onto a piece of paper on a flat surface.
- Check sizes of new brushes. Compare the length of an old brush with the length of a new brush. If the old brushes caused the motor malfunction, they should be worn down 1/32 inch or more, compared to the new brush length.
- Put in the new brushes. Blow the dust out of the brush holders and drop the new brushes in.
- Reposition the contact springs in the brush holder slots.
- Test motor operation. If the motor does not operate with normal voltage applied, lift the contact springs slightly and allow them to snap back. This will drive the brushes into position in case something prevented free movement of the brushes into contact with the commutator. This should cause the motor to operate.
- Replace the cover. Return the cover to its original position, taking care not to pinch any wires. Insert the-cover-screws and tighten them with the jewelers screwdriver. Do not overtighten the screws.

If a DC motor must be replaced, first mark the terminal polarity, before disconnecting wires, to be sure the new motor is installed right.

3.3.8.3 AC/DC High Speed Motors. Small universal AC/DC high speed motors, which have brushes and commutators, are frequently used to power sirens and vibrating horns. If one siren or horn fails while others in the same circuit work, the motor brushes and commutator probably require service. The brushes must be replaced and the commutator may have to be turned down on a lathe to eliminate low points caused by arcing.

3.3.8.4 Synchronous AC Motors. Synchronous AC motors, frequently used in the time/date stamp of paper tape recorders, have no brushes or commutators. Bearings are generally lubricated for the life of the motor. If the motor fails, it must be replaced. Replacement involves removing two to four mounting screws and unsoldering, or otherwise disconnecting, the two motor power wires.

3.3.9 Lamps/Visual Indicators. Fire alarm system lamps and visual indicators are either incandescent, tungsten filament lamps, or light emitting diodes (LEDs). Filament lamps have been used for many years; LEDs have only been used for alarm equipment since the early 1970s. In some cases, neon lamps may also be used.

3.3.9.1 Filament Lamps and LEDs. The lamps and LEDs used in alarm equipment are usually rated for a higher voltage or current than supplied. The light output is less than the rated value, but the life of the lamp or LED is greatly extended. In general, replacement of LEDs is required less often than replacement of lamps. Equipment with several lamps or LEDs usually has a lamp test feature. By pressing a momentary switch, all the good lamps light; bad lamps can be detected. If there is no lamp test feature or to confirm the lamp test results, both incandescent lamps and LEDs can be checked with an ohmmeter.

Remove the colored plastic or glass lens if there is one. Check the manufacturer's instructions to avoid lens damage. Some glass and most plastic lenses are removed by pulling straight out with the fingers. Some glass lenses are removed by unscrewing them in a counterclockwise direction. To remove lamps, use a lamp removal tool available from the lamp supplier or one made by cutting off a 1- to 2-inch piece of electrical insulating tubing ("spaghetti") which fits snugly over the lamp. Most smaller lamps pull straight out. Do not remove lamps with a pair of long-nosed pliers or you will cause a shattered glass envelope or a marred plastic lens to the LED.

Make ohmmeter checks of incandescent lamps on the x1 or x10 resistance scale. The measurement between the two lamp terminals or between the single terminal and the base should be a few hundred ohms or less. If the lamp filament is burned out, the resistance reading will be infinite. An ohmmeter check of an LED will show infinite resistance in one direction and 10 to 500 ohms in the other direction, depending on the meter scale used. (The x10 or x100 scales are probably best for this check.)

3.3.9.2 Neon Lamps. Neon lamps, sometimes used as AC power pilot lamps, cannot be checked at the low voltages produced by an ohmmeter. If a neon lamp does not glow, measure the voltage across the terminals to see if the lamp is receiving voltage (usually 120 VAC). If it is, replace the lamp. Frequently, neon lamps have a bayonet type base which requires that you press in on the lamp, rotate it counterclockwise about one quarter of a turn, and pull out to remove the lamp. The lens that covers a neon lamp may be a permanent part of a lamp and socket assembly. If it is not, unscrew the cover counterclockwise to remove.

3.3.9.3 Total Assembly Lamps. Some pilot lamp assemblies must be entirely replaced if the lamp fails. These lamps may have a self-locking feature, so that when the assembly is installed, it is only necessary to press it into a snug fitting hole in a metal panel. When in position, the base

snaps into place. To remove, go to the back of the lamp and compress the locking tabs with long-nosed pliers and push the total assembly out from the back of the panel.

Some total assembly lamps are held in place by a sheet metal spring clip, called a "Tinnerman nut." During installation, the lamp assembly is inserted through a hole in the panel and the spring clip is pushed onto the lamp assembly from the back of the panel until the lamp is held firmly in place. Removal is very difficult and may destroy the spring clip. If there is adequate free access to the back of the panel, it may be possible to pry first one side and then the other side of the spring clip away from the back of the panel with a thin screwdriver until the lamp can be removed from the panel. For final removal, the wires must be disconnected. If the spring clip has been destroyed when removing the old lamp, replace it with a new one. In catalogs, the spring clip would probably be categorized as hardware and listed as a "Tinnerman nut." To be sure you have the proper size, measure the diameter of the lamp base at the point just behind the panel.

3.3.9.4 Lamp Sockets. If there is a panel light problem and the lamp is good, the problem may be in the lamp socket, especially if there is a rechargeable battery and a charging circuit in the same cabinet as the lamp. The battery charging fumes may cause some corrosion or oxidation to form on the contact surfaces in the lamp socket. If the battery is a lead/acid type, wipe out the inside of the socket with the end of a paper towel slightly moistened with a mild solution made of a teaspoonful of baking soda in a cup of warm tap water. If the battery is nickel/cadmium, use a mild solution made of a teaspoonful of vinegar in a cup of tap water.

A lamp should fit snugly into its base or socket. Disconnect AC and DC power to the panel before touching sockets. If a lamp is loose, check for distorted metal parts inside the lamp socket. Restore metal parts in a socket to their original condition with tweezers or small long-nosed pliers. If necessary, compare the defective socket with a known good socket.

3.3.10 Wiring. If original installation was made properly, little maintenance should be required for the wiring between fire alarm control units and the various devices connected to them. During installation, excess tension used in pulling cables in conduit can cut the outer jacket of the cable and break individual conductors. Cuts in the cable jacket may allow moisture into the cable and cause a partial short circuit between conductors if their insulation is also damaged. Such wiring faults cause more serious operating problems on higher voltage systems. It is sometimes necessary to replace a whole section of cable, rather than take the time to try and locate a fault.

After initial installation, the most frequent wiring problems occur at the wire terminations in the control units, at the initiating devices, and at the indicating devices. These are the points where wires are most frequently disconnected for tests or replacing defective equipment and the wires are damaged in reconnecting to the terminals.

Screw terminal connections should be snug, but not so tight that they cut into the wire. Sometimes it is best to cut off a damaged end and carefully strip the insulation from the new end, with wire strippers of the proper size or adjustment for the wire size being used. If a solid conductor is cut into by the strippers, even slightly, a future break may occur. Future breaks can also occur due to vibration or flexing of the wire at a weakened point.

When replacing a section of wire or cable, the old wire or cable can be used as a "puller." Mechanically connect the old section to the new as firmly and neatly as possible and tape the connection for smoothness so that, when pulling the old section out and the new section into the conduit, the lump formed by the connection will not get caught in the conduit. Be sure loops or tangles do not form as the new section is pulled into the conduit.

3.3.11 Meters. Meters often are used to indicate supply voltage and charging current for rechargeable batteries. In general, they are not high precision meters, so they are only serviced for obvious malfunction, such as sticking at a constant reading.

To check meters, use a reasonably accurate separate test meter with a scale similar to that of the meter being checked. The test meter is called the "standard meter" in the remainder of this section. Before connecting the standard meter, be sure the scale is adequate for the voltage or current to be used in the test. If a multimeter is used as the standard meter, check the AC or DC and current or voltage scale selections. An example of judging the adequacy of a scale for the purpose follows: To check a DC voltmeter with a 0- to 30-volt scale being used to read a normal voltage of 24 to 25 volts, if you use a multimeter with 10- and 50-VDC scales as the standard meter, the 50-VDC scale is adequate; the 10-volt scale is not. Both the standard meter and the tested meter are subjected to the normal 24 to 25 volts, which is off scale for a 10-volt scale, allowing no direct comparison.

To check the voltage, connect the standard meter to the same terminals as the meter being checked. It should not be necessary to disconnect any existing wires. The normal voltage should appear on both meter scales. Turn off the AC power to the power supply. If there are no standby batteries, both meter readings should drop to zero. If there are standby batteries, the meter readings should drop only slightly initially and continue to drop very slowly as the batteries discharge. There should be a fuse in one of the main battery output conductors. Removing the fuse should cause the meters to drop to zero.

The characteristics to be observed during checking are:

- Obstruction of Meter Deflection.

The meter should read smoothly. There should be no hanging-up, even momentarily, at a reading different from the standard meter reading.

- Accuracy.

Check the approximate accuracy of the meter being checked, in comparison to the standard meter, at the zero and normal readings at least.

If the 0-volt readings do not match, both 0-volt readings should be adjusted to exactly zero, while tapping the meter face to remove friction effects. Usually a small adjuster for zero adjustment, which can be operated with a small screwdriver, is located at the pivot point for the meter needle. Make this adjustment before

comparing higher scale readings. At a reading near full scale for the tested meter, its reading should be within '10% of the standard meter reading. For example, at a standard meter reading of 25 volts, the tested meter should read in the range 22.5 to 27.5 volts.

- Friction.

Look for excessive friction in the meter being checked. If, for instance, when the voltage on the standard meter drops to zero, the voltage indication on the meter being checked drops only to 5 or 10 volts, and then drops to zero when the meter face is tapped, it indicates excessive friction in the meter pivots. Look for changes in a meter reading when tapping the meter with a finger.

To make the meters deflect for a friction test, disconnect AC power. Remove and replace a battery fuse to cause the meters to drop to zero and then return to their normal reading. Be sure to restore AC power and the fuse at the end of the test.

If a meter has one or more defects, return it to the equipment manufacturer for repair or replacement.

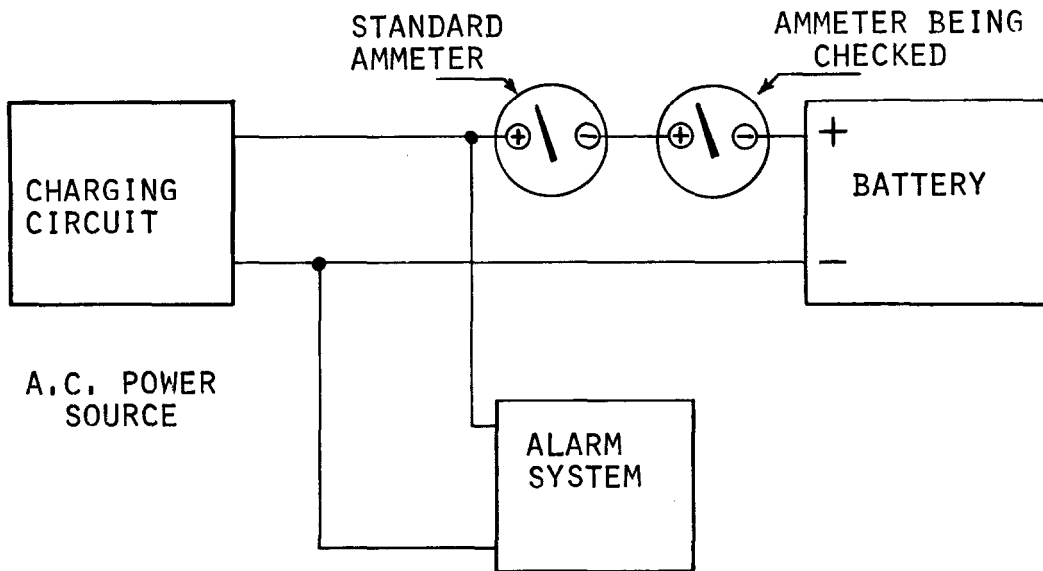
If there is only one meter on a battery charger panel, it is usually an ammeter used to indicate charge or discharge rate of the standby battery. An ammeter on a power supply panel indicates current being drawn from the power supply. Ammeters for battery chargers are frequently zero-centered meters which deflect in both the plus and minus directions, indicating whether the battery is discharging or being charged and how great that current is.

Check the same characteristics for ammeters as for voltmeters, but the method of connecting the standard meter to the circuit is different. For comparison of readings, the same current must flow through the standard ammeter and the ammeter being checked (Figure 3-3). Break the existing ammeter circuit and insert the standard meter in series, observing polarity, after first making sure that the scale of the standard ammeter is adequate.

The standard ammeter may be inserted into the circuit by connecting its two terminals to the fuse terminals and then disconnecting the fuse from the circuit. Keep in mind that the meter and meter fuse, if any, are now the only overcurrent protection for the test. Compare the two ammeters for negative deflection by disconnecting AC power while the standby battery powers the alarm system. Reverse the standard meter connections for an accuracy check of negative deflections, if the standard meter is not also zero-centered. If the battery partial discharge is continued for an hour or two, restoration of AC power will cause a positive deflection of the two ammeter needles to allow a comparison for that part of the meter scales.

3.4 TYPICAL MAINTENANCE CHARACTERISTICS OF CERTAIN EQUIPMENT. Equipment maintenance includes some maintenance of components plus maintenance of the equipment. as a complete assembly.

3.4.1 Building Alarm Systems. Building alarm systems require maintenance for the control and auxiliary units, alarm signal initiating devices, and alarm indicating devices.



NOTE : WITH POLARITIES SHOWN, METERS DEFLECT TO THE RIGHT FOR CHARGING OF THE BATTERY AND TO THE LEFT FOR DISCHARGING, WITH SYSTEM OPERATING AND A.C. POWER CONNECTED, METERS SHOULD SHOW A LOW RATE OF BATTERY CHARGE DEFLECTION SLIGHTLY TO RIGHT OF CENTER).

FIGURE 3-3
AMMETER CHECKING METHOD

3.4.1.1 Line Voltage Control Unit. Line voltage control units are probably the least complex of the control unit types and probably the most dangerous for the maintenance person because of the electrical shock hazard. Even if the operating voltage is only 120 VAC for the fire alarm function, the separate power circuit usually provided for the trouble function may be from a different phase of the AC source, resulting in voltage between the two power circuits of more than 200 VAC. The peak AC voltage, which is also a measure of the shock hazard, would be approximately 300 volts--enough to cause injury or death if the terminals are touched by hand or with uninsulated tools.

The line voltage control unit typically contains most of the common components such as relays, resistors, diodes, transformers, fuses, switches, lamps, and wiring. See Section 3.3 for maintenance information for specific components. Testing of the complete panel should be performed according to the manufacturer's instructions. Many line voltage powered control units have a current limiting resistor and a current cutoff device in the control unit, connected in series with the audible signal devices. The total resistance of the current limiting resistor and the current cutoff device is used to adjust the audible signal circuit output voltage, under load, for the number of audible signal devices actually used.

The cutoff device has two functions: (1) When the audible signal devices sound, the resistance portion of the cutoff device produces heat, which in turn, heats a bimetallic thermostatic element. The bimetallic strip bends as

its temperature rises, and eventually it mechanically unlatches an electrical contact connected in series with the audible signaling circuit. The audible signals stop sounding. The cutoff acts as a timer. (2) When one or more audible signal devices are removed from service and the series circuit is restored without resistance adjustment to compensate for the reduced number, the current through the cutoff device and the total circuit is excessive. (A short circuit somewhere in the audible signal circuit could also cause excessive current.) Heating the bimetallic strip occurs at a fast rate and the circuit opens in a short time, depending on the magnitude of the current. The higher the current, the faster the current cutoff occurs. The cutoff device acts as a circuit breaker. A periodic test of the audible signaling circuit checks the audible signal devices, control unit contacts and cutoff device. For test purposes, the audible devices should be operated until automatic cutoff occurs, if the control unit contains a cutoff. During the audible device operation, watch the cutoff device for arcing at the contacts and for proper operation. If cutoff does not occur within 2 to 15 minutes, the test should be discontinued and the cause investigated.

Occasional visual inspection of the resistor and contacts and contact cleaning are desirable. The visual inspection should include looking for: (1) physical damage to the resistor body and connecting wires due to excessive heat; and (2) deterioration of the contacts because of humid or corrosive atmosphere, excessive current, or improper contact pressure. Heavy current with low contact pressure can cause arcing and excessive contact heating.

The part of the cutoff device most vulnerable to permanent damage is the resistor. If the resistor body is cracked or broken, if lead wires are broken very close to the resistor body, or if the resistor shows no continuity (has infinite resistance) when checked with an ohmmeter, the resistor must be replaced. If the cutoff device cannot be disassembled, the whole device must be replaced. The final measure of acceptability of a component is its proper function. Resistor body deformation or heating until it glows is acceptable if normal function is retained.

3.4.1.2 Low Voltage Control Unit. The low voltage control unit typically contains a rechargeable battery and battery charger, possibly housed in a separate cabinet. In some cases the battery is replaced by a low voltage power supply only. The operating circuits are 6 to 48 VDC powered, with most being 12 to 24 VDC. Recently manufactured control units, suitable for medium to large buildings, are almost all 24 VDC powered.

The components in low voltage control units, which may require occasional replacement or maintenance, are relays, resistors, capacitors, diodes, transformers, fuses, switches, lamps or LED's, meters, and wiring. In addition, a modular control unit will have replaceable modules which plug into the main control unit assembly. The modules vary in construction but usually contain solid state devices mounted on printed circuit boards. Sometimes the modules are sealed, but more often they can be disassembled for repair. Each module may represent one zone or a group of zones or it may perform a nonzoned function such as one of the following:

- Providing a time delay (such as shutting off bells after 15 minutes)
- Providing output contacts for a remote auxiliary function (such as fan shutdown)

- Power transfer (from commercial power to standby power and back)
- Sounding a local trouble buzzer
- Control of audible signal devices
- Providing a reverse polarity alarm output (for remote station connection)

Use the manufacturer's diagrams and servicing information to narrow down any problems to a small area. If a problem can be isolated to one of these modules or if a problem appears to be related to a zone module, the most immediate repair is to replace the module. If the module is not sealed, inspect it for a condition such as an overheated resistor or transistor, a poorly soldered connection, a bent connector pin, or a malfunctioning relay. Repair or replace the parts, resolder the connection, or straighten the connector pin. For other conditions, more difficult to analyze, replace the module. (Keep spares on hand.)

Any soldering that is performed, especially in replacement of solid state devices on printed circuit boards, must be performed with care and in accordance with good commercial soldering practice.

3.4.1.3 Coded Control Units. Coded control units for building alarm systems code the audible alarms using a spring motor or electric motor driven code wheel to open and close switch contacts in the audible signal circuit. The distinctive pattern of sounds produced identifies the type of alarm or the type or location of the initiating device causing the alarm.

If the code identifies a location (zone), the actuated initiating device causes the alarm relay for the zone to operate. The contacts of the alarm relay close, activating the coding motor for the zone. The coding contacts actuated by the coding motor and wheel cause the coded alarm. A coded control unit has one or more coding devices and one or more relays in addition to the components of a noncoded control unit.

To test coding mechanisms, simulate an alarm in each coded zone when normal activities in the building would not be disrupted. Alert the fire department to the testing. Listen to the audible signal for each zone to be sure that each coded signal is a clearly readable pattern. Also check that the coded signal is properly identified in the fire department records. For coding contact problems, see the contact maintenance part for relays (Section 3.3.1). For coding devices sealed in a modular assembly, a malfunction requires module replacement.

To replace a modular coding mechanism, or "coder," unplug the module and plug in the replacement. If it is an open construction type coding mechanism, it may involve disconnecting (and tagging for future reference) four or more wires and removing three or four mounting screws before the mechanism can be lifted out. Carefully pack the removed mechanism and return it to the manufacturer for repair.

To install the replacement mechanism, reverse the steps used to remove it. Reconnect wires to the correct terminals. If coding problems are traced directly to the coding wheel, they may be corrected if the mechanism is not sealed. The code wheel on many unsealed, selective coded or master coded devices is made from a standard code wheel by cutting out teeth on the perimeter of the wheel. The remaining teeth determine the signal pattern.

If audible signals occur which do not fit the desired pattern, it could be caused by incomplete removal of teeth from the code wheel. The areas where teeth were removed may be smoothed down using a small file to eliminate any undesired audible signals.

Irregular sounding of audible signals in a march-time coded system could be caused by irregular motor drive or by improper adjustment of the coding contacts. There are various types of code wheels and methods of causing coded signals. For maintenance of other types of coders and for coding contact adjustment procedures, refer to the manufacturer's instructions.

3.4.1.4 Annunciators. Components of annunciators that may require maintenance are lamps or other visual indicators (LEDs), relays, switches, wiring, diodes, and resistors. Test the annunciator when the fire alarm initiating devices are tested so alarm location identifiers can be checked.

Some annunciators "lock in" the alarm indication. The indicator remains lighted after the initiating device and fire alarm control panel have been restored to the no-alarm condition. For these types, confirm that the individual zone indicators stay lighted after the initiating device is restored and that the reset switch at the annunciator panel, usually a momentary switch, turns off the zone indicator lamps. If there is an audible device at the annunciator, be sure it operates with the alarm and is turned off by the silencing switch and the reset switch.

3.4.1.5 Recorders. Recorders are usually found in a base alarm system, rather than in a building alarm system. However, a large building fire alarm system may have a recorder to provide a permanent record of each change of status for all the devices in the system.

- Paper Tape Recorder (Register). This equipment (Figure 2-3) usually contains the following common components: resistors, capacitors, diodes, switches, motors, lamps, and wiring. The paper tape recorder normally also contains transistors and solenoids and may contain integrated circuits and either printed circuit boards or circuit boards with standoff terminals or eyelets. The older units may use transistor/capacitor or relay/capacitor timing circuits to control paper tape movement after the last pulse of a signal and allow convenient reading of the signal; newer units may use an integrated circuit (IC) for this. Older units may use terminal-to-terminal mounting of components using standoffs or eyelet terminals; newer units generally contain printed circuit (PC) boards for component mounting. The older units frequently use a heavy, high current DC motor and worm gear drive to feed the tape through the recorder; the newer units generally use a lightweight low current DC motor with more efficient pinion gears for speed reduction. The oldest units have a spring wound drive motor.

If some problem in recorder operation occurs, such as a failure of the paper tape transport mechanism or a failure to properly record coded pulses, disassemble the recorder to inspect circuit boards, mechanical assemblies, and other components.

Disconnect all electrical cords from the recorder and remove the roll of paper tape. Typically, the cover can be removed by removing one to four screws, depending on the manufacturer.

Obvious defects to be looked for during an inspection are: excessively worn gearing, discolored insulation on solenoids and relay coils from overheating, cracked and discolored diodes and resistors, and discolored areas on circuit boards indicating overheating of components in the area. If there is a defect in one of the common components, test and repair following the instructions in Section 3.3. Solenoid malfunction is indicated by distortions in the code pulses on the paper tape or a failure to produce the coded pulses. If a sound is heard or some mechanical vibration is felt during reception of a coded signal, it is usually a mechanical defect causing the malfunction. Solenoids can be treated as relays with no contacts, their coil resistance is lower. Since solenoids accomplish some mechanical action, friction can cause sticking problems. Solenoid coil resistance will usually be 1 to 50 ohms.

Inspection should include looking for signs of solenoid shaft wear and missing parts such as retaining rings. Solenoid action is characterized by abrupt motion and stopping, so forces are high and can cause wear, breakage, and distortion of mechanical parts. Generally, when there are mechanical defects, cleaning, light lubrication, and readjusting or replacing distorted or broken parts are recommended.

If the recorder fails to operate, look for an interruption of power, such as a blown fuse, an open circuit breaker, or a broken wire in a connecting cable to the recorder. The usual means of electrically connecting the recorder to the other signal receiving equipment is a coiled, stretch cord with connectors at both ends. Check this cord and its connectors for broken connections with an ohmmeter without disassembling the recorder. Use the $\times 1$ resistance scale, and check to see that all functional connector pins show continuity to the corresponding connector pin at the other end of the cord. If the cord continuity is good, check for voltage at the paper tape drive motor terminals under signal receiving conditions. If there is voltage, but the motor does not run, replace the motor. If no voltage reaches the motor under signal receiving conditions, there is probably a defective component in the circuit which controls the drive motor operation.

If there is a relay in the recorder control circuit assembly that controls the running time of the drive motor, motor running problems might be eliminated by cleaning and/or burnishing the relay contacts. Sometimes the paper tape drive fails to move the paper tape far enough after a signal is received for the signal to be completely seen. The amount of running time usually can be adjusted using a variable resistor which is accessible only when the recorder is partially disassembled. Adjust running time with the recorder connected to the equipment for signal receipt, the paper tape installed, and the recorder cover removed to allow access to the adjustable resistor. The recorder should start running when the first pulse of a simulated or actual signal is received and continue until the last pulse received is within view. If the running time cannot be adjusted to satisfy this requirement, there is probably a defective capacitor in the timing circuit or a bad connection to the capacitor. If the timing circuit contains an integrated circuit timer, a defective integrated circuit can be the cause of the timing problem.

If the paper tape drive runs too long after a signal is received, the problem may be caused by residual magnetism in the timing relay. Adjusting the relay to increase the necessary holding force to keep the contacts in the energized state can sometimes cure this problem, if such adjustment does not adversely affect operation otherwise. Demagnetization of the relay is another possible solution, if demagnetizing equipment is available.

If the paper tape drive runs too long, and no timing relay is present, the switching device (transistor, integrated circuit, or other solid state device) is probably defective and must be replaced. Gear wear should affect only the paper tape drive. If the actual wear is minor, cleaning and lubrication with a grease recommended by the manufacturer may be adequate to extend gear life. Obtain a set of replacement gears when wear is first noticed.

If a channel of a paper tape recorder fails to record the incoming pulses (first confirm with a voltmeter or other means that the signal is arriving at the recorder), and the solenoid appears to be normal (coil resistance is normal and insulation is not discolored), look for defective components in the solenoid drive circuitry. Typical defects are a shorted diode connected directly across the solenoid coil or a shorted or open switching transistor.

Paper tape recorders accumulate paper dust which can interfere with mechanical functions of the recorder. Any time the recorder is partially or totally disassembled for repair, blow or wipe away the paper dust.

- Alpha-Numeric Printers. Alpha-numeric printers require specialized equipment for maintenance. It is usually best to return the equipment to the manufacturer for repair.

If the printer uses an inked ribbon, replace the ribbon if it is damaged or worn or when the printing becomes faint. Carefully follow the manufacturer's instructions when changing the ribbon. Check to see that the ribbon reverses direction when it reaches the end to avoid damage to the new ribbon. For any repairs to alpha-numeric printers that are beyond the scope of the manufacturer's literature, return the printer to the manufacturer.

3.4.1.6 Remote Signal Transmitters. Remote signal transmitters that are part of the equipment installed in a building system are actuated by electrical signals from the building alarm system. The remote signaling contacts are wired into a remote station signaling circuit which terminates at a signal receiving station, usually located in a base fire station. Two basic types of remote signaling transmitters are in wide-spread use:

- Reversal Signal Transmitter. The reversal signal transmitter consists of only a relay and a power supply for the remote signaling circuit. The power supply may have a standby battery. It may also have a current limiting feature to prevent power supply damage if the remote signaling circuit (usually a telephone line pair of conductors) is short circuited. Without the current limiting feature, a short circuit can cause a very high current and damage the transmitter relay contacts, the power supply and/or battery, and remote signaling circuit wiring.

A frequent symptom of a power supply problem for a reversal signal transmitter or remote signaling circuit is failure of the remote station to receive a full alarm signal. If the transmitter operates properly, and the alarm does not, the power supply current limiting feature may have been adjusted to limit the current to such a low value that the alarm receiving equipment is unable to distinguish between alarm and trouble. The current to each receiver must be adjusted since the receiver modules for each alarm connection vary in the way they react to current near the critical level.

For instance, suppose that 4 milliamperes (mA) of current is considered to be normal for the remote signaling line. For an alarm signal, the current reverses direction and remains at about 4 mA. It may be that the particular receiving module requires 4.5 mA to cause an alarm signal. The receiving module indication would change from normal to trouble instead of changing to an alarm indication. To correct the problem, measure the current under normal and alarm conditions and increase the current limit setting to allow about 1 mA more current to flow in the normal and alarm conditions. If necessary, the current may be increased to 6 or 8 milliamperes (mA).

The retest to confirm proper function should include operating with the standby battery connected and AC power turned off to insure that the standby battery can supply the normal and alarm currents. Otherwise, the alarm may indicate trouble at the receiving module when there is a power failure at the transmitting location. If the standby battery is not adequate, either service it or replace it with a higher voltage battery that meets the requirements.

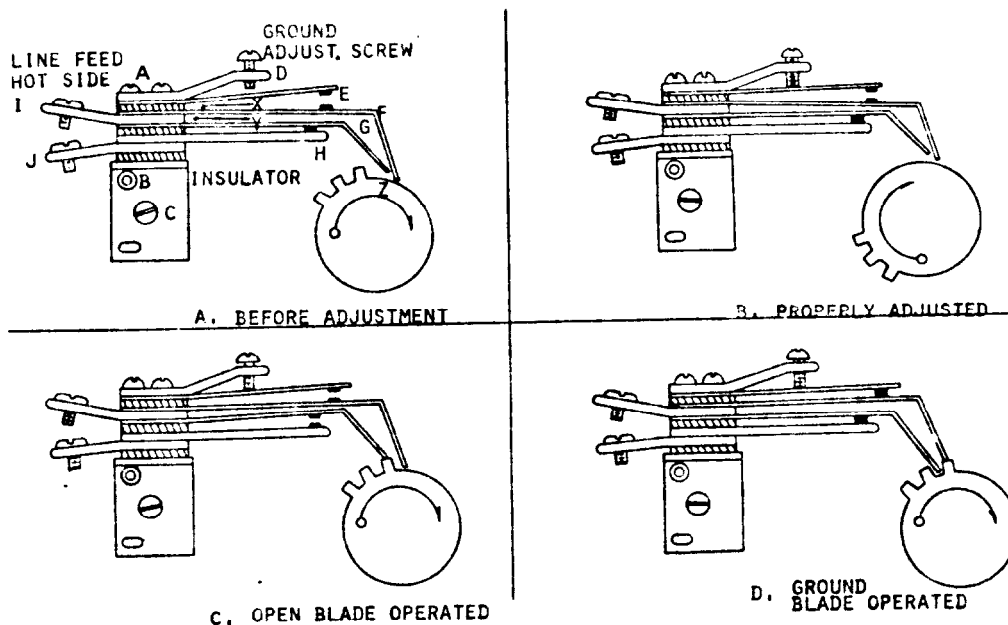
Poor adjustment of the reversal relay contacts and a poor choice of terminals used for incoming power and outgoing reversal signal can cause a serious problem. Refer to Figure 2-26, which is a reversal signal transmitting circuit. If the reversal relay contacts are wired as shown, the potential problem does not exist, but if the reversal relay contacts are reversed, with common terminals connected to the power supply and the two jumpers connected on the telephone line side instead of the power supply side, a serious problem can occur. When the power supply is connected to the two common terminals and an alarm condition occurs, a direct short circuit on the power supply results causing damage to power supply components or even an electrical fire. If the short circuited signal line power supply is the same one that supplies the reversal relay coil current, the sudden heavy electrical load may prevent the relay from completing the alarm signal switching action. It may remain in the partially transferred, shorting condition until burning wire insulation starts a fire.

The short circuit is more likely to occur when two single pole relays are used instead of a double pole relay as the reversal signal transmitter. With two single pole relays, the likelihood of one relay operating before the other is even greater, increasing the chances for a malfunction.

To correct the problem, exchange the power supply terminal pair for the telephone line terminal pair so that the relay common terminals are connected to the telephone line pair, as shown in Figure 2-26. The relay contact adjustment is no longer critical, and the threat of damage and fire is eliminated.

- Coded McCulloch Fire Alarm Transmitter. These transmitters require maintenance of the spring driven motors (escapement mechanisms) and DC electric motors. Coding contacts also require periodic maintenance (cleaning) of the sort described for relay contacts (see Section 3.3.1.).

The coding contacts may require adjustment at installation or later, when the code wheel is changed or if the transmitter is disassembled for other maintenance (Figure 3-4).



- A 1. TIGHTEN ASSEMBLY SCREWS AT POINT A TO INSURE GOOD CONTACT THROUGH THE ASSEMBLY AND GOOD GROUND CONTACT TO THE MOVEMENT.
2. CHECK GROUND ADJUSTMENT SCREW IN BRACKET D FOR TIGHTNESS. IT SHOULD BE MORE THAN FINGER TIGHT. IF NOT, REMOVE SCREW AND SQUEEZE SLOTTED BRACKET TO TIGHTEN THREADS. REPLACE SCREW PART WAY.
3. CRIMP GROUND CONTACT BLADE E AT POINT X WITH A SPRING BENDER TOOL TO MAKE IT PRESS AGAINST GROUND ADJUSTMENT SCREW. THIS PUTS TENSION ON BLADE TO HELP IT HOLD FINAL ADJUSTMENT.
4. CRIMP BLADE G AT POINT Y TO GIVE GOOD CONTACT PRESSURE AGAINST CONTACT BLADE H (ABOUT 50 GRAMS). IF TOO MUCH PRESSURE IS USED AT THIS POINT, IT WILL PUT UNNECESSARY DRAG ON THE MOVEMENT AND CUT DOWN THE NUMBER OF ROUNDS AVAILABLE.
5. CUT FOUR TEETH FROM THE CODE WHEEL TO GIVE A CLEAR SPACE, LOOSEN SCREWS B AND C IN MOUNTING BRACKET AND ADJUST CONTACT ASSEMBLY TO PLACE CONTACT BLADE G ABOUT HALF DEPTH ON THE CODE WHEEL. TIGHTEN SCREWS B AND C SECURELY.
6. CRIMP BLADE F AT POINT X SO THAT THE BLADE IS ALMOST FULL DEPTH ON THE CODE WHEEL. THIS GIVES GREATER AIR GAP BETWEEN CONTACTS E AND F TO HELP PREVENT ACCIDENTAL GROUNDS.
7. TURN GROUND ADJUSTMENT SCREW DOWN TO BRING THE GROUND CONTACT WITHIN ABOUT 3/64TH INCH OF THE CONTACT ON BLADE F.
8. ADJUST BLADES F AND G AT POINT Z, IF NECESSARY, TO GIVE THE PROPER OPEN-GROUND-OPEN ACTION. THEIR TIPS SHOULD BE WITHIN ABOUT 1/64TH INCH OF EACH OTHER AT POINT Z.
9. RUN CODE WHEEL, BLADES F AND G SHOULD OPERATE ALTERNATELY TO GIVE A CLEAR OPEN (ABOUT 1/64TH INCH) AND A GROUND. THE GROUND BLADE E SHOULD MOVE UP SLIGHTLY AS IT IS PUSHED BY BLADE F. THIS INSURES GOOD GROUND CONTACT AND A WIPING ACTION. DO NOT SET DEEP ENOUGH TO CAUSE TOO MUCH DRAG ON THE MOVEMENT.
10. THE HOT SIDE OF THE LINE SHOULD BE FED INTO THE CENTER CONTACT AT POINT I. THE HOT SIDE CAN BE DETERMINED BY OPENING THE LINE AND TESTING TO GROUND. THE CENTRAL OFFICE SWITCH MUST BE KEPT IN THE NORMAL POSITION FOR THIS TEST BECAUSE WHEN THE SWITCH IS MOVED TO THE OPEN POSITION BOTH SIDES OF THE LINE BECOME HOT.
11. WHEN A SHUNT SWITCH IS USED FOR SHUNT NONINTERFERING CONNECTION OF TRANSMITTERS SHOULD BE CONNECTED TO THE BOTTOM CONTACT LUG AT POINT J.

B SHOWS THE CONTACT ASSEMBLY IN THE NORMAL ADJUSTED POSITION.

C SHOWS THE CONTACT ASSEMBLY OPERATED BY A CODE WHEEL TOOTH TO GIVE AN OPEN DASH ON THE RECORDER.

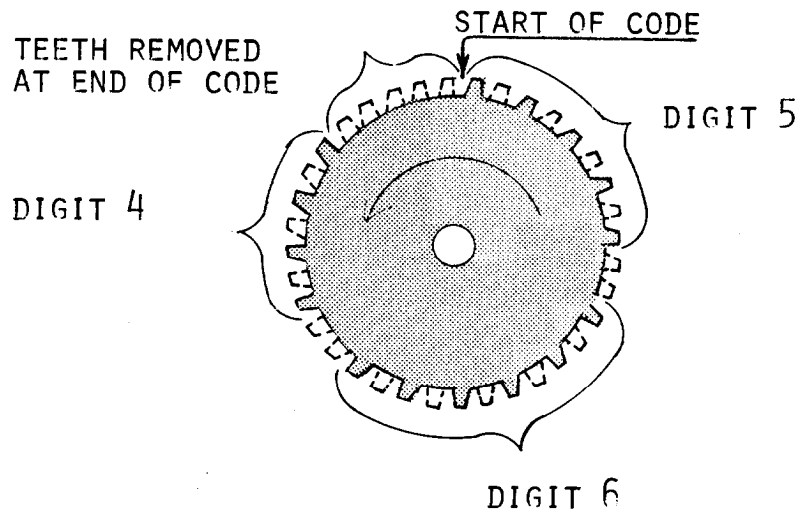
D SHOWS THE GROUND ACTION{ A SLIGHT OVERLAP OF OPEN AND GROUND ACTIONS WILL STILL PRODUCE A GOOD SIGNAL,

FIGURE 3-4
MCCULLOH CODING CONTACT ADJUSTMENT

A set of McCulloh coding contacts consists of several flexible metal blades (usually four) held together to form a closed circuit and an open circuit. Two of the contact blades (usually the middle two blades) are electrically common but are arranged to flex separately. The separate flexing action is necessary in order to obtain the separation of circuit opening and grounding functions required for proper signaling under normal and circuit fault conditions. The open and ground contact blades are staggered so that each code wheel tooth will open the line, close the line, and then ground the line. This ideal adjustment gives some safety factor to insure that the coded signal will not be lost under any circuit single fault condition and even some circuit double fault conditions. An adjustment of the contacts which gives some overlap of the "open" and "ground" conditions will reduce the amount of safety factor for receipt of a readable signal under circuit fault conditions, but a readable signal will still be produced.

The safety factor in the adjustment is perhaps most important in the case of a long signaling circuit line. Capacitance due to the long line can cause considerable lag in operation of relays in the signal receiving equipment. The final measure of the quality of the coding contact adjustment is the receipt of proper signals by the remote receiving station with the mode selector switch in "normal" and "open" positions.

If the best possible coding contact adjustment does not produce readable signals at the receiver and the signaling line is long (perhaps 10 miles or more), it may be necessary to use a double-spaced code wheel to allow for the capacitance lag in relay operation to obtain a readable signal (Figure 3-5).

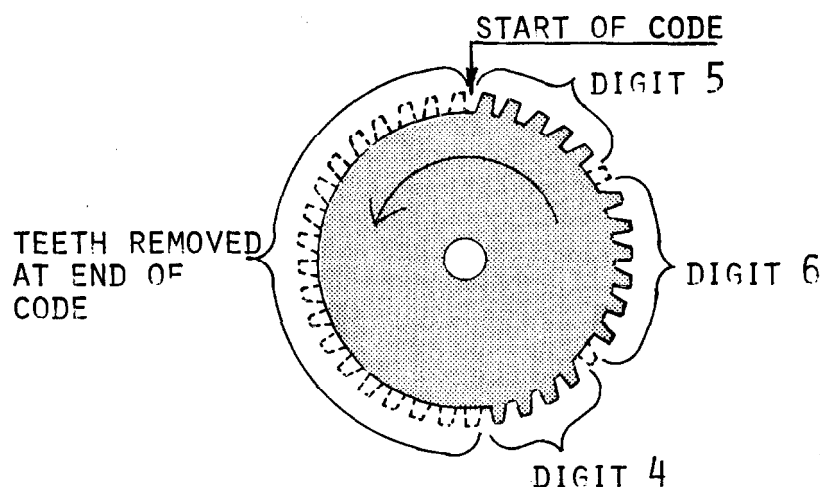


NOTES: CODE REPRESENTED IS 5-6-4, DOTTED TEETH ARE THOSE REMOVED TO OBTAIN THE DESIRED CODE, ARROW ON CODE WHEEL INDICATES DIRECTION OF ROTATION DURING CODE TRANSMISSION, NOTE SLANT OF TEETH RELATIVE TO WHEEL ROTATION.

FIGURE 3-5
MCCULLOH CODE WHEEL WITH DOUBLE TOOTH SPACING

Code wheels are frequently made from phenolic or nylon. When new, the wheel has its maximum number of teeth. When coding a new transmitter or changing the code of an old transmitter, keep the code wheel hub assembled to the code wheel because the code wheel is trued to the hub by the manufacturer. Otherwise, the effective adjustment of the coding contacts may change during a rotation of the code wheel. If the code wheel is removed from the hub, replace it in the same orientation as it was.

Code the wheel by removing one or two teeth to separate each digit from the next digit of the code and remove all remaining teeth at the end of the code which are not needed. See Figures 3-5 and 3-6, which show typical code wheels as cut. Note that the digit 5 is represented by five teeth, 6 is represented by six teeth, and 4 is represented by four teeth in both cases shown. The teeth may be removed using wire cutters or a jig saw and smoothed afterwards with a file or sandpaper. Be sure the stubs of removed teeth are low enough to prevent touching of the contact blades after the code wheel is reassembled to its drive shaft, or else false pulses will be transmitted.



NOTES: CODE REPRESENTED IS 5-6-4, DOTTED TEETH ARE THOSE REMOVED TO OBTAIN THE DESIRED CODE, ARROW ON CODE WHEEL INDICATES DIRECTION OF ROTATION DURING CODE TRANSMISSION, NOTE SLANT OF TEETH RELATIVE TO WHEEL ROTATION.

FIGURE 3-6
MCCULLOH CODE WHEEL WITH NORMAL TOOTH SPACING

Some types of McCulloch code wheels and coding contacts do not require adjustment or maintenance, such as code wheels consisting of printed circuit contacts on an insulating disc. The initial setting of the code is made by removing the foil contact strips from the disc. The detailed adjustment and maintenance procedures for any other types of McCulloch coding contacts must be obtained from the manufacturer's data sheets.

Tests of transmitters in auxiliary signaling systems or for automatic fire alarms on remote station signaling systems should be performed monthly. Bi-monthly tests are recommended for transmitters in manual fire alarms on remote station signaling systems.

3.5 GENERAL PROCEDURES--TESTING AND MAINTENANCE OF CONTROL AND AUXILIARY UNITS

3.5.1 Frequency. All control and auxiliary equipment should be visually inspected monthly for tampering, damage, and general condition. In buildings normally occupied, each initiating and signaling circuit should also be operationally tested monthly. Equipment in warehouses or buildings not normally occupied should have an operational test of each initiating and signaling circuit quarterly. These tests should be coordinated with sample tests of heat and smoke detectors, manual fire stations, and audible signal appliances to minimize duplication.

3.5.2 Procedures. Visual inspections should include checking for missing indicator lamps and lenses, and physical damage. Moving and functional parts, such as cabinet locks, lenses, and meters, should not be painted and may require replacement if painted. Operational tests should either be combined with periodic fire drills or all affected parties must be informed prior to tests to avoid disruption of normal activity and unnecessary dispatching of fire vehicles.

Periodic operational tests should include a realistic test of an alarm initiating device in each zone. On systems that monitor the sensitivity of detectors, the detector sensitivity should be checked every 6 months by reading the analog voltage on the control panel printer or at the annunciator display circuit board. Proper operation of zone alarm indicators should be noted. Proper operation of audible signal appliances in each major occupied space should be confirmed. Confirm proper operation of remote transmitters observation, if practical, and by communication with receiver operating personnel.

3.5.3 Troubleshooting Circuit Faults. Circuit faults may occur in the connection to the power source, in the initiating circuits, and in the alarm indicating circuits. Locating the fault depends on which of these is involved and specifically if, in the case of initiating and indicating circuits, the circuit is a four-wire "Class A," a two-wire "Class B," or a series normally closed circuit.

3.5.3.1 Power Circuit Ground and Short. A ground fault in the power source wiring will typically cause the building circuit breaker for the fire alarm system to trip. The equipment will continue to operate on a standby battery, if provided. If the battery is discharged or if no battery is provided, the equipment affected will be out of service and fire alarm protection will be nonexistent. Because battery capacity is limited and complete discharge should be avoided to prevent permanent damage to the battery, repair the fault immediately.

3.5.3.2 Power Circuit Open. An open circuit fault in a line supplying the fire alarm system will cause signs of power failure but circuit breakers or fuses may show normal conditions. If the fire alarm control unit has a power failure or trouble signal feature, it will be activated, indicating that a problem exists. Figure 3-7 is a troubleshooting chart for this condition.

3.5.3.3 Unsupervised Initiating Circuit Faults. Faults in unsupervised circuits have no capability to indicate a trouble condition, so troubleshooting is only attempted after a problem occurs. The only sign of a fault is a false alarm or no alarm when conditions for an alarm exist. A typical unsupervised initiating circuit with two initiating devices is shown in Figure 2-35.

- Short Circuit. A short circuit between initiating circuit wires causes a false alarm because it simulates an alarm condition. Initiating circuit wires otherwise become connected to each other only during an alarm through the closing of the normally open contacts of an initiating device. See Figure 3-8 for troubleshooting information.
- Open Circuit. In the loop type initiating circuit shown in Figure 2-35, an open circuit fault condition might require two faults in order to cause circuit malfunction, depending on the fault location. If a broken wire occurs at point D, both initiating devices continue to operate normally. Due to the lack of supervision, there is no indication of the broken wire. The open circuit is detectable only by disconnecting the four initiating circuit wires at the control unit or annunciator and measuring the two loops for continuity with an ohmmeter.

Some unsupervised initiating circuits are composed of two parallel wires with normally open initiating devices connected across them, as in Figure 2-35, but with the circuit dead-ended at the last device. In these circuits an open circuit fault is immune to most practical detection and troubleshooting methods, except for periodic testing of initiating devices, especially those which are electrically more distant from the source.

- Ground Fault. One ground fault in an unsupervised circuit would not cause a functional problem. If the alarm system were intentionally grounded at some point, for a functional or safety reason, an additional circuit ground might cause a malfunction or another circuit problem indication, such as a blown fuse. Two circuit grounds on opposite sides of the initiating circuit, such as at points F and G in Figure 2-35, would be a short circuit, causing a false alarm.

Initiating circuit ground faults can be located and repaired using the method of troubleshooting described for power circuits in Figure 3-9.

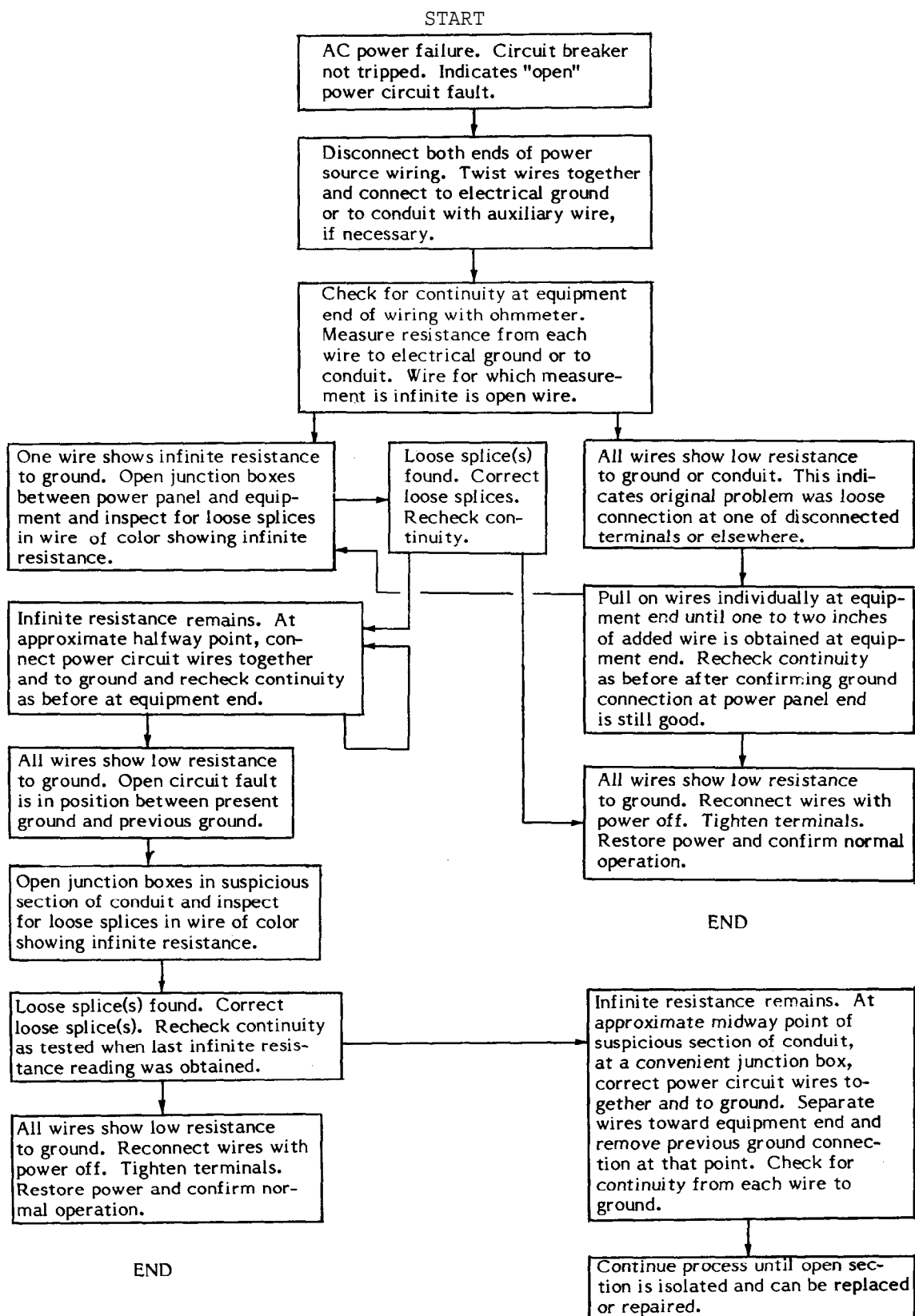


FIGURE 3-7
TROUBLESHOOTING CHART FOR POWER CIRCUIT OPEN FAULT

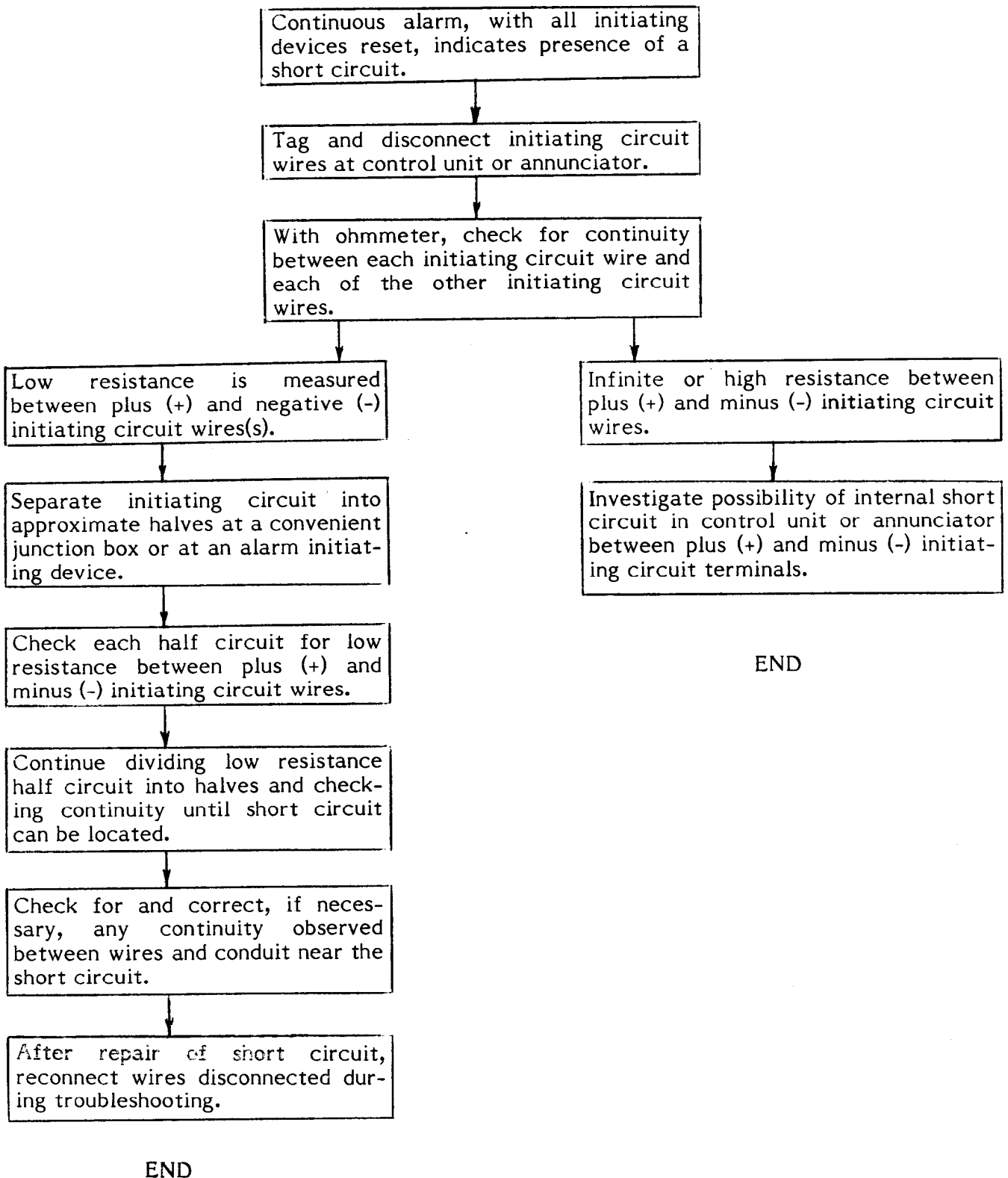


FIGURE 3-8
TROUBLESHOOTING CHART FOR A SHORT CIRCUIT FAULT
IN AN UNSUPERVISED INITIATING CIRCUIT

START

AC power failure. Circuit breaker trips.

CAUTION NOTE:
Insure power is off
before touching wires.

Disconnect both ends of power
source wiring and tape equip-
ment ends of wire separately.

Check for continuity to conduit
from source end of power wires
using ohmmeter R x 1 scale.

Measurable low resistance con-
firms ground fault in wiring.

Separate circuit wiring in halves at
a convenient junction box, taping new
exposed ends. Check both halves of
each wire for continuity to conduit.

Wire section which shows continuity
to conduit is the grounded section.
Redivide it in halves and check both
halves as before.

When grounded section is found,
examine wire and splices for bare
wire which could explain the con-
tinuity to the conduit.

Insulate bare wire with insulating tape
or insulate splice with wire connector
or insulating tape. Recheck continuity
to ground to confirm repair.

Reconnect disconnected wires and
restore power.

END

Infinite resistance rules out power source
ground as the cause of the power failure.

Check for continuity between each power
circuit wire and each of the other power
circuit wires.

Measurable low resist-
ance for any reading
indicates short cir-
cuit between power cir-
cuit wires for which
low reading was obtained.

See Figure 3-10
for short circuit
troubleshooting.

Infinite resist-
ance readings rule
out power source
wiring as the cause
of the power failure.

Check equipment
for internal short
circuit or ground.

END

FIGURE 3-9
TROUBLESHOOTING CHART FOR POWER CIRCUIT GROUND FAULT

3.5.3.4 Series Normally Closed Initiating Circuit Faults. These circuits are one type of supervised circuit.

CAUTION NOTE:

Insure power is off
before touching wires.

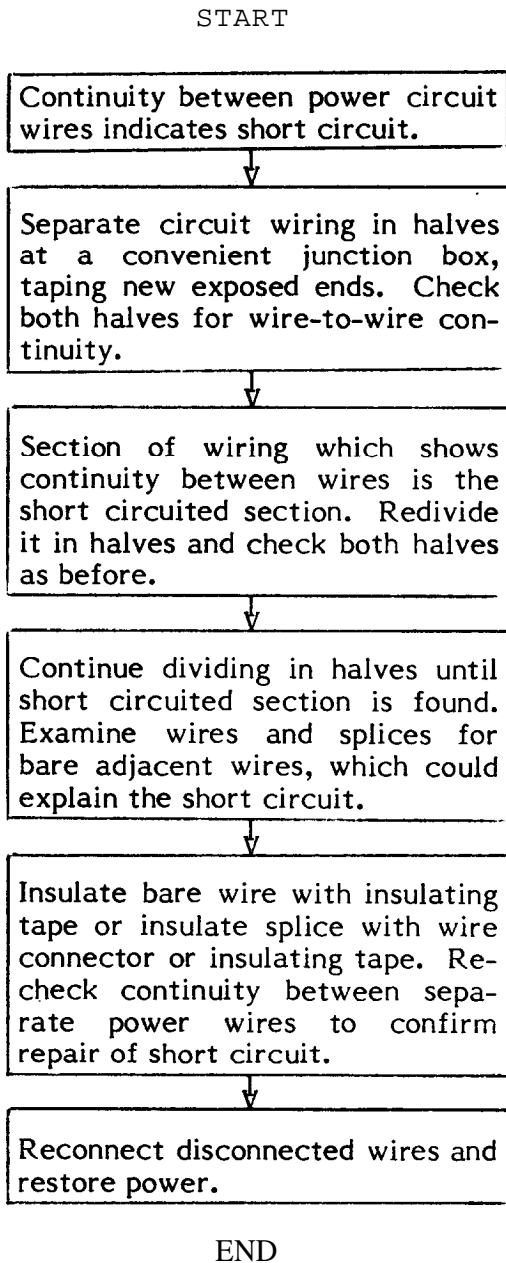


FIGURE 3-10
TROUBLESHOOTING CHART FOR A SHORT
CIRCUIT FAULT IN A POWER CIRCUIT

- Short Circuit. Typically, a short circuit fault on a series normally closed circuit causes no indication at the control unit or annunciator,

A short circuit between the two sides of the initiating circuit loop would only bypass and deactivate the devices beyond the short circuit without causing any change in the circuit condition as seen from the source. The only effective way of detecting the fault would be periodic testing of initiating devices, especially those electrically distant from the source. If a device does not work during this routine test, test additional devices to determine if only the one device tested or a whole section of the circuit is defective. If a group of devices distant from the control unit or annunciator does not work, a short circuit fault exists and its location is between the most electrically remote operative device and the electrically nearest inoperative device. (See Figure 3-10).

- Open Circuit. An open circuit fault on a series normally closed circuit causes an alarm to be indicated by the control unit or annunciator. The two sides of the circuit loop of Figure 2-33 normally are run together through the same conduit and junction boxes, which makes it practical to measure continuity as instructed in Figure 3-11. In searching for the fault, look especially for loose connections at splices and at initiating device screw terminals. Follow the troubleshooting steps in Figure 3-11.
- Ground Fault. A single ground fault on a normally closed initiating circuit should not cause a problem, but there might be a circuit trouble indication at the control unit or annunciator if ground fault detection is a feature of the equipment. Even a single fault should be corrected so that a possible additional fault will not cause a serious defect in the alarm system. Two ground faults result in a short circuit between the two faults.

Follow these steps for troubleshooting a ground fault:

1. Tag and disconnect the initiating circuit loop at the control unit or annunciator terminals.
2. With an ohmmeter, check for continuity between each end of the circuit loop and an unpainted spot on the electrical conduit or another ground, such as a cold water pipe. Continuity confirms that at least one circuit ground fault exists. An infinite reading (no continuity) suggests looking in the control unit or annunciator for the ground fault.
3. At a point that is electrically about halfway between the source and the end of the circuit loop, break both sides of the loop by disconnecting wires at a convenient initiating device or junction box. Check for continuity between each wire and ground separately.
4. Each time continuity to ground is found, move toward the ground fault at a new test point halfway between the present test point and the end of the circuit loop and check as in Step 3 until the fault is found and repaired.
5. Reconnect all disconnected wires and test alarm using an initiating device farther from the control unit or annunciator than the repaired fault.

3.5.3.5 Class B Initiating Circuit Faults. A Class B initiating circuit is shown in Figure 2-24. It is a supervised circuit in that an open circuit fault is indicated at the control unit or annunciator as trouble.

- Short Circuit. A short circuit between two points on the same side of the circuit does not harm system operation and is normally not detected unless the short circuit also involves one or more ground faults. A short circuit between wires on opposite sides of the circuit causes an alarm. A clue to this condition is the fact that an alarm condition exists for an initiating circuit, but inspection shows that none of the initiating devices connected to that circuit have operated.

Follow these troubleshooting steps:

1. Tag and disconnect the initiating circuit loop at the control unit or annunciator terminals.
2. Measure the initiating circuit resistance with an ohmmeter. A value of 100 ohms or less confirms a short circuit. The lower the value, the closer to the source the fault is located. A measurement equal to the end-of-line resistor value or slightly higher is normal and suggests looking in the control unit or annunciator for the fault. (Determine the proper value of the resistor, usually 1,000 to 2,000 ohms, from reference materials on the equipment.)

START

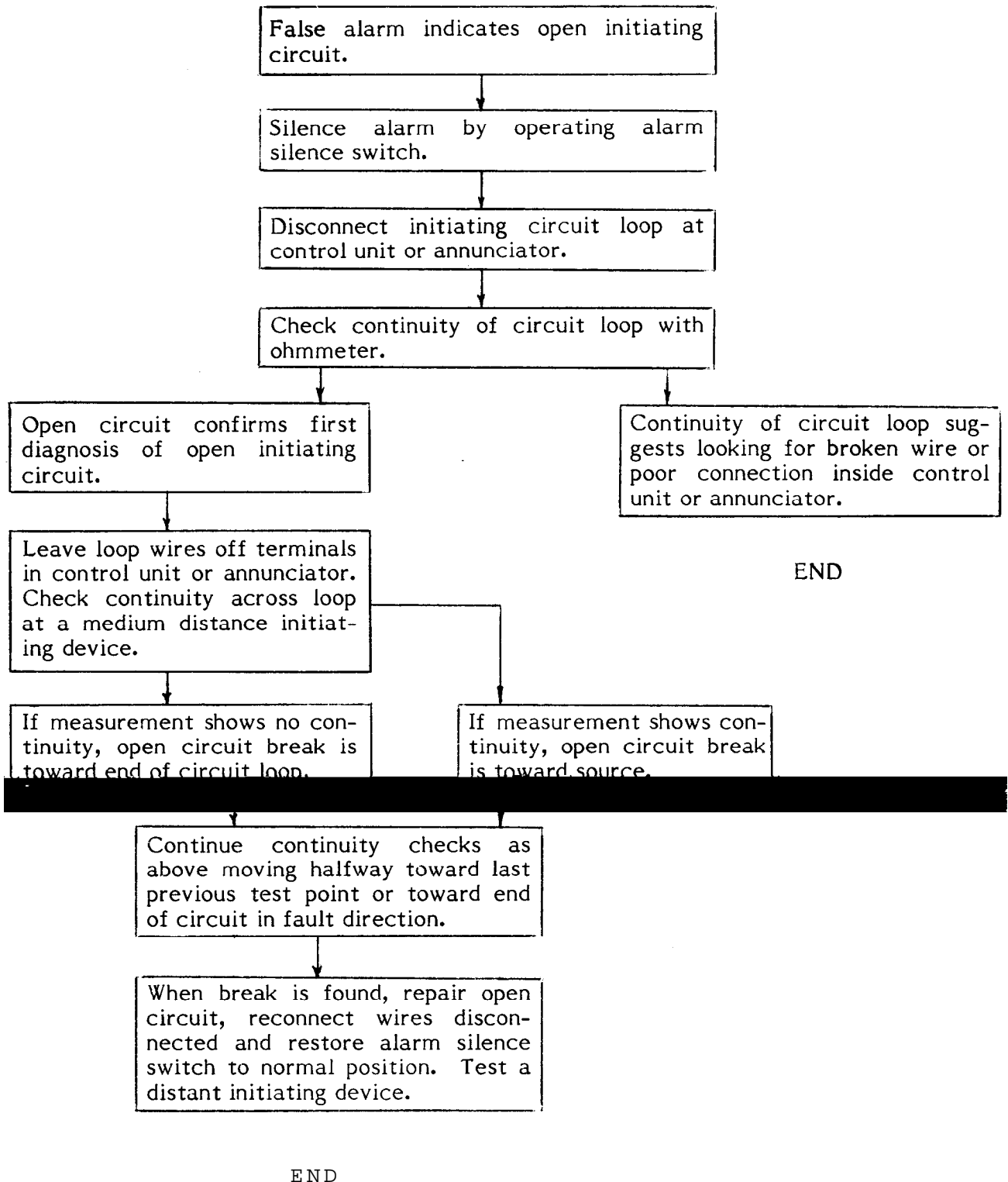


FIGURE 3-11
TROUBLESHOOTING CHART FOR AN OPEN CIRCUIT FAULT
IN A SERIES NORMALLY CLOSED CIRCUIT

3. If resistance measured is low, confirming a short circuit, move to a point that is electrically about halfway between the source and the end-of-line resistor for the next resistance measurement. A very low resistance, near zero, indicates the short circuit is quite near the test point. A resistance of 50 to 100 ohms indicates that the circuit is a long one of smaller gauge wire and that the short circuit fault is near the end of the circuit. At each new test location, break both sides of the circuit by disconnecting wires at a convenient initiating device or junction box. Measure circuit resistance in the direction toward the end of the circuit.
4. Low resistance measured from the second location, less than 100 ohms, indicates the short circuit is still farther toward the end- of the circuit. High resistance, approximating the end-of-line resistor value, indicates that the short circuit is closer to the control unit.
5. Continue moving toward the short circuit, dividing the circuit approximately in halves each time, and repeat the measurement of resistance toward the end of the circuit using the guidelines in Step 4 as the rule for interpreting each succeeding measurement.
6. When the fault is located, repair it, reconnect the disconnected wires, and restore the circuit to normal service.
- Open Circuit. An open circuit fault in a Class B circuit stops the supervising current. The trouble relay at the control unit or annunciator deenergizes and trouble indicators are activated for the circuit. Initiating devices closer to the control unit or annunciator than the open fault may continue to function. Devices beyond the fault cannot operate. If an open circuit fault occurs, turn off any audible trouble signals by operating the trouble silence switch.

Continue troubleshooting by using the following steps:

1. Tag and disconnect the initiating circuit loop at the control unit or annunciator terminals.
2. Measure the initiating circuit resistance with an ohmmeter. An infinite reading (no change in meter reading with meter disconnected from the circuit) confirms an open circuit fault. A measurement equal to the end-of-line resistor value, or slightly higher, is normal and suggests looking in the control unit or annunciator for the fault.
3. If the open circuit fault is confirmed, leave the two circuit -wires off their terminals, taped separately. Move to a point that is electrically about halfway between the source and the end-of-line resistor for the next resistance measurement. Choose a convenient initiating device or junction box and measure resistance across the two sides of the initiating circuit. If the measurement is still infinite, the open circuit fault is still farther along the circuit toward the end-of-line resistor. If the measurement is now about equal to the

end-of-line resistor value, the open circuit fault is between the present measurement point and the source.

4. Move toward the fault to a point electrically about halfway between the present measurement point and the end-of-line resistor or the source and measure resistance across the circuit.
 5. Infinite readings indicate the open circuit fault is toward the end-of-line resistor from the new test point. Readings approximating the end-of-line resistor value indicate the open circuit fault is toward the source.
 6. Continue taking new readings, advancing toward the fault. Look especially for loose connections at splices and at initiating device screw terminals.
 7. When the fault is located, repair it, reconnect wires at the control unit or annunciator, and restore alarm service.
- Ground Fault. A single ground fault on a Class B initiating circuit should not cause any malfunction, but a circuit trouble indication might be caused at the control unit or annunciator if ground fault detection is a feature of the equipment. Even a single fault should be corrected so that a possible additional fault will not cause a serious deficiency in the alarm system. Two ground faults on opposite sides of the initiating circuit cause a short circuit between the two faults. Follow troubleshooting directions described earlier for a short circuit fault. Troubleshooting for a single ground fault is accomplished by following the steps listed in section 3.5.3.4.

3.5.3.6 Class A Initiating Circuit Faults. A Class A initiating circuit is shown in Figure 2-30. Supervision of the circuit is such that a fault is indicated at the control unit or annunciator as trouble and initiating devices continue to function.

- Short Circuit. A short circuit fault between two points on the same conductor would not affect system operation and would not be detected unless the short circuit involved one or more ground faults. A short circuit between two points on different loops of the circuit (between the A and B loops of Figure 2-30) causes an alarm indication at the control unit or annunciator. The alarm can be identified as a false alarm by the fact that no initiating devices are actuated as a result of an abnormal condition.

Follow these troubleshooting steps:

1. Tag and disconnect the initiating circuit wires at the control unit or annunciator.
2. With an ohmmeter check for continuity between the A and B loops. The two A ends and the two B ends show continuity with no fault present. Continuity between A and B loops confirms a short circuit fault. If there is no continuity between A and B

loops , look for a short circuit in the control unit or annunciator. Note the color coding of the wires for future reference.

3. If there is a short circuit, move to a point electrically about halfway between the source and the most distant initiating device on the circuit for the next continuity check with the ohmmeter. At a convenient initiating device or junction box, break the four wires at splices and/or screw terminals and check for continuity between A and B loops, both on the wires leading back to the source and on the wires leading toward the more distant initiating devices. (Use the previously noted color coding to identify wires.) If continuity is found between A and B loops only toward the more distant devices or only toward the source, the disconnected wires may be reconnected before moving to the next test point. If continuity is found in both directions, there are at least two short circuit faults to be repaired, one in each direction.
 4. Each time continuity is found between A and B loops, move in the direction indicated by the continuity to a new test point about halfway between the present test point and the last previous test point or the end of the circuit in that direction (source or end-of-line resistor). Look especially for pinched and damaged wires and faulty initiating devices.
 5. When the fault is located, repair it, reconnect all disconnected wires, perform a test using one of the distant initiating devices on the circuit, and restore the alarm system to service.
- Open Circuit. An open circuit fault in a Class A circuit activates trouble indicators for the circuit. Initiating devices on both sides of the fault still operate and are capable of causing an alarm. If an open circuit fault occurs, turn off the audible trouble signals.

Continue troubleshooting by using the following steps:

1. Tag and disconnect the initiating circuit wires at the control unit or annunciator.
2. With an ohmmeter, measure the initiating circuit loop resistances for both the A and B loops. An infinite resistance reading on either loop confirms an open circuit fault. If continuity is found on both loops, this suggests an open circuit fault inside the control unit or annunciator and further troubleshooting effort should be made in that direction.
3. If an A or B loop open circuit fault is confirmed, note the color coding of the wires for future reference. Insulate the bare ends of the initiating circuit wires with tape. Move to a point that is electrically about halfway between the source and the most distant initiating device on the circuit for the next continuity check with the ohmmeter. At a convenient initiating device or junction box, identify the A and B loops (color coded) . Check continuity of both loops with the ohmmeter. If

an infinite reading is still registered for one of the loops (it should be the same loop as before), the open circuit fault is still electrically farther from the source. If continuity is now shown for both loops, the fault is back toward the source.

4. Move in the direction of the fault to a new test point about halfway between the present test point and the end of the circuit in that direction (source or most distant initiating device).
 5. Each time A and B loop continuity is checked, an infinite reading indicates the fault is further from the source. If continuity is obtained for both loops, the fault is toward the source. Continue moving toward the fault, checking for continuity and loose or broken wires, especially at junction boxes and initiating devices.
 6. When the fault is located, repair it, reconnect wires at the control unit or annunciator, test the alarm system using a distant initiating device on the circuit, and restore alarm service.
- Ground Fault. Ground fault detection is frequently provided in control units with Class A initiating circuits. A ground fault causes a trouble indication or a ground fault indication on control units having the ground fault detection feature. A single ground fault will not cause a malfunction or deactivation of any portion of the alarm system, but should be corrected so that a possible additional fault will not cause a serious deficiency in the alarm system. Two ground faults on different loops of the initiating circuit result in a short circuit fault. First troubleshoot and repair the short circuit fault, and then check for a possible remaining ground fault. Troubleshooting for a ground fault may be accomplished by the following the steps in section 3.5.3.4 for each loop.

3.5.4 Indicating Circuit Faults. Operating tests of indicating circuits to locate and repair faults are best performed after normal working hours to avoid disruption of normal activities, unless tests are combined with regular drills.

3.5.4.1 Unsupervised Circuits. Except for false alarms, symptoms of faults in unsupervised circuits occur only during tests of the alarm system. Therefore, test alarm systems with unsupervised initiating and indicating circuits regularly.

- 1 Short Circuit. A short circuit fault in an unsupervised indicating circuit is very difficult to detect by the usual test methods because the normal circuit resistance is quite low. A short circuit is just a low resistance in parallel with the low resistance indicating devices.

Symptoms would be a blown fuse at the control unit or power supply during a routine system test or fire drill and audible devices that do not operate as loudly as usual.

If you suspect a short circuit fault, the following troubleshooting steps may help locate the fault:

1. There may be several indicating circuits powered from one power supply or fuse in the control unit. Separate the several circuits from each other by tagging the wires and disconnecting them from the control unit terminals. It may be necessary to make continuity measurements to confirm that the wires from each circuit are tagged separately. Compare the resistance readings for the indicating circuits using the xl resistance range of the ohmmeter. If there is a short circuit fault, that circuit should have a lower resistance reading than the others. Insulate the individual bare wires of the circuit being checked with tape.
 2. Determine how the circuit wires are routed using the best available information you may have to trace the wire or conduit route. Move to a point electrically about halfway between the control unit and the most distant indicating device for the next check. At a convenient initiating device or junction box, separate the wires leading back to the control unit from those leading to the more distant indicating devices by disconnecting them at device terminals or at splices. Measure circuit resistance in both directions. The short circuit fault should be in the direction of the lower resistance.
 3. Move toward the fault to a new test point about halfway between the present test point and the last test point or the end of the circuit in that direction (power source or last indicating device). Separate the wires toward the control unit from those leading away from the control unit and again measure the circuit resistance on the xl scale of the ohmmeter in both directions. The fault will be in the low resistance direction.
 4. Continue to move toward the fault, looking for pinched and damaged wires and for improper connections at indicating devices. Make careful measurements at each new test point, since the difference between normal and abnormal resistance may be only slight.
 5. When the fault is located, repair it, reconnect all wires, test the indicating devices, and restore the alarm system to service.
- Open Circuit. The effect of an open circuit fault on an unsupervised indicating circuit depends on whether the circuit is composed of two loops, with each end of a loop connected to the same terminal at the control unit, or of two parallel wires, which start at the control unit and terminate at the last indicating device. In the loop circuit, two open circuit faults in the same loop would deactivate indicating devices between the two faults. In the two wire parallel circuit, one open circuit fault near the control unit would deactivate all the indicating devices. The only sign of an open circuit fault is the failure of one or more indicating devices during an alarm system test or a fire drill.

The following troubleshooting steps will help locate the fault:

1. Operate the system test or drill switch at the control unit and check operation of each indicating device on the suspected faulty circuit.
 2. Check the circuit connections at any device with intermittent or weak signals. If a group does not work, check circuit connections at the working and nonworking devices at each end of the group. Make sure that terminal screws are clean and snug and that there are no broken wires at the devices checked.
 3. If the fault was not located in Step 2, check the wiring between working and nonworking devices, looking especially for poor splice connections at junction boxes.
 4. If all the indicating devices on a circuit do not work, check for a blown fuse or poor connections at the control unit or at the first indicating device on the circuit.
 5. When the open circuit fault is found, repair the fault and retest the indicating circuit to confirm that all indicating devices work properly.
 6. In loop type indicating circuits, disconnect the circuit wires at the control unit and check continuity in both loops. If infinite resistance is found in one loop, reconnect circuit wires at the control unit, except for one end of the infinite resistance loop. Retest the indicating circuit as in Step 1, and additional steps as necessary, to locate and repair the fault. Retest continuity on the previously open loop, reconnect the loose wire at the control unit, retest the indicating circuit and devices, and restore the alarm system to service.
- Ground Fault. A single ground fault in an unsupervised indicating circuit may not cause any symptoms unless the indicating circuit is AC line powered. If the ground fault is on the "hot" side of the AC circuit and the indicating circuit is tested, a fuse or circuit breaker at the control unit or at the power panel supplying the alarm system will "blow." A ground fault on the neutral side of the indicating circuit causes no symptoms. Two ground faults on opposite sides of the indicating circuit are also a short circuit. Troubleshooting for the short circuit may be accomplished as described earlier. Troubleshoot for a ground fault by following the steps in section 3.5.3.4.

3.5.4.2 Series Normally Closed Circuits. Series normally closed indicating circuits are usually supervised and powered by the AC line. Trouble indicators at the control unit indicate a fault. Other symptoms of a fault are failure of some or all indicating devices on the circuit to operate and a blown fuse or circuit breaker. Blown fuses and circuit breakers indicate excessive current and are caused by short circuit and ground faults. An open circuit fault causes a trouble indication and all the indicating devices fail to operate. To avoid shock, disconnect AC power to the faulty indicating circuit before starting to disconnect wires and make continuity measurements.

- Short Circuit. A short circuit fault near the end of an indicating circuit may not immediately actuate overcurrent devices (fuse, circuit breaker, or current cutoff/timer), but will deactivate one or more indicating devices at the end of the indicating circuit away from the control unit. The fault is located between the last working indicating device and the first nonworking indicating device.

If overcurrent devices are actuated and prevent locating the fault, it may be necessary to reset overcurrent devices, position someone near the indicating devices to tell which ones operate, and operate the test or drill switch. Repeat the test until the fault is located.

- Open Circuit. An open circuit fault causes all indicating devices on the circuit to fail. Fuses do not blow unless there is also a ground or short circuit fault on the control unit side of the open circuit fault. In that case, check for and repair the ground or short circuit fault first.

To locate and repair an open circuit fault on a normally closed indicating circuit, the troubleshooting steps in section 3.5.3.5 may help.

- Ground Fault. Since series normally closed indicating circuits are usually AC line powered, during an alarm one side of the circuit is grounded. Any additional ground on the circuit may short circuit some indicating devices, resulting in the symptoms of a short circuit fault. Check for and repair the short circuit fault first. Troubleshooting for a ground fault may be accomplished by following the steps in section 3.5.3.4.

3.5.4.3 Class B Indicating Circuit. A Class B indicating circuit is shown in Figure 2-29. An open or short circuit fault in a Class B indicating circuit causes a trouble indication at the control unit. A ground fault may also cause a trouble indication if ground fault detection is a feature of the control unit.

- Short Circuit. A short circuit between two points on the same side of the circuit does not affect operation of indicating devices and is normally not detected unless some other fault is also involved. A short circuit between two points on opposite sides of the circuit causes an increase in supervising current. Trouble is indicated at the control unit. A short circuit fault may be caused by pinched or damaged wires or by a defective diode at an indicating device. Turn off the trouble indication at the control unit and locate the fault by following the troubleshooting steps in section 3.5.3.5. Polarity of the ohmmeter for this measurement is important.
- Open Circuit. An open circuit fault in a Class B indicating circuit eliminates the circuit supervisory current, causing a trouble signal at the control unit. Operating the test or drill switch turns on any indicating devices between the control unit and the open circuit fault. Note which indicating devices operate and examine the wiring for the fault. Look for loose connections at splices and devices, and for damaged wire, then:

1. If none of the indicating devices operate, the fault is either in the control unit or between the control unit and the nearest indicating device. Disconnect the circuit at the control unit terminals and measure circuit resistance twice, using both polarities of the ohmmeter. If you do not get an infinite reading, the open circuit is probably inside the control unit. If the open circuit fault is between the control unit and the first indicating device, an infinite reading with both polarities should result.
 2. If some indicating devices nearer the control unit operate while others further from the control unit do not, the open circuit fault is located between the last working and the first nonworking devices.
 3. If all the indicating devices work, but trouble is indicated at the control unit, measure circuit resistance at the control unit, using both ohmmeter polarities, with the circuit wires disconnected from the control unit. If an infinite reading is obtained with one polarity and a low reading with the other, the end-of-line resistor may be damaged or disconnected. It is usually located at or very near the farthest indicating device on the circuit.
 4. If one indicated device does not work and there is no trouble indication, the device is probably defective. An open circuit fault in the internal diode or in the coil of the device are likely defects.
- Ground Fault. A ground fault in a Class B indicating circuit causes a trouble indication at the control unit if ground fault detection is a feature of the equipment; otherwise the fault may not be noticed. Two ground faults on opposite sides of the circuit are also a short circuit fault. Follow the short circuit troubleshooting steps and repair the short circuit fault first.

Troubleshooting for a single ground fault is the same as described for a ground fault in a Class B initiating circuit except that for indicating circuits, there is no annunciator.

3.5.4.4 Class A Indicating Circuit Faults. Figure 2-32 shows a Class A indicating circuit. If a single open or ground fault occurs, trouble is indicated at the control unit and all the indicating devices continue **to** operate. If there are two faults or a short circuit fault, indicating devices may fail to operate.

- Short Circuit. A short circuit fault in a Class A indicating circuit causes a trouble indication at the control unit, blown indicating circuit fuses or circuit breakers, and indicating devices to fail. Turn off any trouble signals and begin troubleshooting following the same steps as for a short circuit in a Class A initiating circuit. Measure continuity of the A and B circuit loops to confirm loop identification. Check continuity between A and B loops using both polarities of the

ohmmeter. If continuity "is shown for both polarities, the short circuit fault is confirmed.

- Open Circuit. The only symptom of an open circuit fault in a Class A indicating circuit is a trouble indication at the control unit. Turn off the trouble signals and begin troubleshooting as with an open circuit in a Class A initiating circuit.
- Ground Fault. Ground fault detection on indicating circuits is frequently provided as a feature in control units with Class A indicating circuits. A trouble indication or a specific ground fault indication at the control unit would be the first sign of such a fault. A single ground fault does not cause a malfunction or deactivate indicating devices but should be corrected promptly so that a possible additional fault does not cause a deficiency. Two ground faults on different loops of an indicating circuit are also a short circuit fault. First follow troubleshooting steps for a short circuit fault.

Troubleshooting for a ground fault may be accomplished by following the steps in section 3.5.3.4. If continuity to ground is found for one end of a loop, continuity to the same ground fault may be found for all four wires, depending on ohmmeter polarity with respect to diodes in the indicating devices. If there is a ground fault indication at the control unit, but no continuity to ground is found for the indicating circuit, the ground fault may be in the control unit, an annunciator, or an initiating circuit.

3.5.5 Wire Pulling. If wiring is in conduit and a circuit fault is found, it may be necessary to pull a section of wire out of the conduit and replace it with undamaged wire. If the fault is in a short section of conduit between two junction boxes, remove the junction box covers and isolate the damaged section of wiring by disconnecting it at the two junction boxes. Attach new wire of the same color coding as the old to one end of the damaged section of wiring at one of the open junction boxes. (The strength of the mechanical attachment is important, as well as its smoothness and small diameter.)

Pull the new wire into the conduit by pulling on the unattached end of the damaged wiring. When the new wire is in place, detach the damaged wire and cut the new wire to the proper length, allowing some slack. Test the new wire to insure that there is no continuity to the conduit and no continuity between conductors before connecting it to the original undamaged wiring.

If the junction boxes are far apart, if there are bends in the conduit, or if the wire fits snugly in the conduit, it may be necessary to apply wire pulling compound to the wire as it is pulled into the conduit to reduce friction.

3.6 FIRE ALARM INITIATING DEVICES. The most numerous components of an alarm system are usually initiating devices, They are throughout protected buildings and are more exposed to physical damage than other parts of the system.

3.6.1 Manual Fire Alarms. Manual devices are probably the most abused initiating devices because they must be easily accessible to the personnel in the protected building. Vandalism and painting of normal devices along with other routine painting are the most frequent problems. Vandalism often

results in breakage of a replaceable element made of glass or fiber. The element is not essential for proper function in many manual devices but may provide a psychological deterrent to mischievous operation. Painting can interfere with smooth functioning of the exposed moving parts and prevent operation of screws, locks, and latches used to open and reset manual devices for testing.

3.6.1.1 Noncoded Fire Alarm Boxes. Figure 2-12 is an example of a noncoded fire alarm (manual pull) box. Single action and double action devices are both used. The single action device requires one action to cause an alarm and a replaceable glass rod is broken with each operation. The double action device requires two actions to cause an alarm: first, the glass window is broken; second, the alarm lever is pulled. The glass elements in these two examples are necessary parts to retain all the design features. Both devices can be tested without breaking the glass parts by opening the device. Manual fire alarm boxes may require loosening a set screw or operating a latch with a hexagonal (allen) wrench, screwdriver, or key to open.

3.6.1.2 Coded Fire Alarm Boxes. Figure 3-12 shows a coded fire alarm box. Coding mechanisms are described in Section 2.2.2.2, "Initiating Devices and Circuits." Some comments on maintenance of coding driven mechanisms are given in Section 3.3.8, "Motors." The device in Figure 3-12 uses a replaceable glass rod, which can be replaced without disassembling the box and is not essential for proper operation. Resetting requires one-quarter turn of an allen screw at the top, allowing the front to swing down and providing access to the mechanism. To reclose the device, reverse the operation.



FIGURE 3-12
CODED FIRE ALARM BOX

3.6.1.3 Testing and Maintenance. Manual initiating devices should be visually inspected monthly for physical damage due to vandalism, accident, and painting. At this time, count the devices to be sure that none have been concealed or removed. Correct deficiencies promptly. Test repaired units by mechanical operation and transmission of local and remote signals, without glass breakage. Be sure to inform building and fire department personnel that the test is to be performed.

Test all manual devices on a rotation schedule so that all devices are tested semiannually, except for coded manual fire alarm boxes which should all be tested annually. Some devices should be tested each month, at least one from each initiating circuit (zone) or remote signaling circuit, in the case of coded fire alarm boxes. Keep accurate records of devices tested, their locations, and the rotation scheme. Store a copy of building system diagrams and test records in the control unit.

3.6.1.4 Troubleshooting. Troubleshooting for initiating circuit problems was described for Control and Auxiliary Units. If, during testing, proper signals are not obtained, determine if the problem relates to a circuit, a device or a control unit. If other nearby devices in the same circuit work properly, the problem is

probably in the device. In noncoded manual devices, the only electrical causes of malfunction are the circuit connections to the device and the switch. If an exact replacement spare switch or complete device is available, make an immediate repair or replacement. Be sure the terminal connections are snug and that wires are not broken at the terminals. Breaks can occur inside the insulation. To check, tug slightly on each wire near the terminal. If an immediate repair cannot be made, tag the device as inoperative and return as soon as possible to complete the repair.

If the complete device is replaced with a new one and the only defective component in the old device is the switch, order a replacement switch, repair the old device, and keep it as a spare. Always test repaired or replaced devices and correct mistakes in reconnecting wires or in analyzing the problem.

In coded manual devices, check the proper functioning of the drive mechanism by operating the device and listening for constant speed of the mechanism. Next, look at the code wheel or cam for irregularities which might explain any malfunction. Examine circuit connections to the device for loose or intermittent connections. Look for absence of a ground wire connection and check the continuity to ground for existing ground wires at the coding device, if a ground connection is required. See Section 3.4.1.6, "Remote Signal Transmitters," for information on other defects in coding contact adjustment and cleaning.

3.6.2 Automatic Fire Alarm Initiating Devices. Most problems relating to automatic devices are from painting and accidental damage. Painting sensing devices slows or inhibits their response to a fire. Some damage results from vandalism, especially to the larger, more visible devices such as smoke detectors. Even minor damage can prevent internal parts from operating. All these devices require routine inspection and testing and some require periodic cleaning.

3.6.2.1 Spot Type Heat Actuated Detectors. Spot type heat detectors have a detecting element or elements which respond to temperature conditions at a single point.

- Fixed Temperature Detectors. These detectors are shown in Figures 3-13, 3-14 and 3-15. Spot type fixed temperature detectors are mainly used in unattended spaces to detect smoldering fires which increase the temperature of a detector above its design value, usually 135 to 145 or 185 to 200 F. The higher temperature devices are used in spaces which may reach high temperatures under ordinary conditions, such as boiler rooms, attics, or cooking areas.

The device usually is actuated by melting or fusing an element made of a fusible metal alloy. Actuated devices usually can be detected by visual examination. In the devices of Figures 3-13 and 3-14, the smaller diameter part in the center drops away. In Figure 3-15, the dimple becomes a hole when the detector operates.

Fixed temperature devices are often "non-restorable"; that is they are designed for one time operation, then the whole device (Figures 3-13 and 3-15) or the element (Figure 3-14) needs to be replaced.

- Rate Compensated Detectors. This type of detector is shown in Figure 3-16. For low rates of temperature change (up to 5 F per minute), rate compensated detectors operate like fixed temperature detectors. For higher rates of temperature change,

the detector anticipates the rise in temperature to its set point and operates faster than the usual fixed temperature detector. It automatically resets and is reusable when the temperature drops below its design value. There is no difference in external appearance between an actuated device and an unactuated device, so that its status must be checked electrically.



FIGURE 3-13
LOW PROFILE HEAT DETECTOR

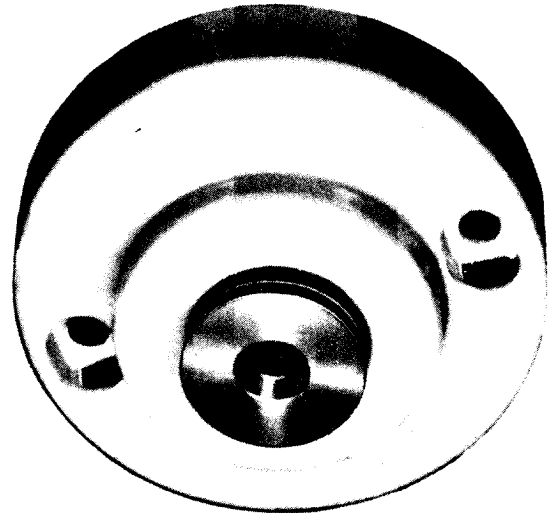


FIGURE 3-14
REPLACEABLE ELEMENT FIXED
TEMPERATURE HEAT DETECTOR

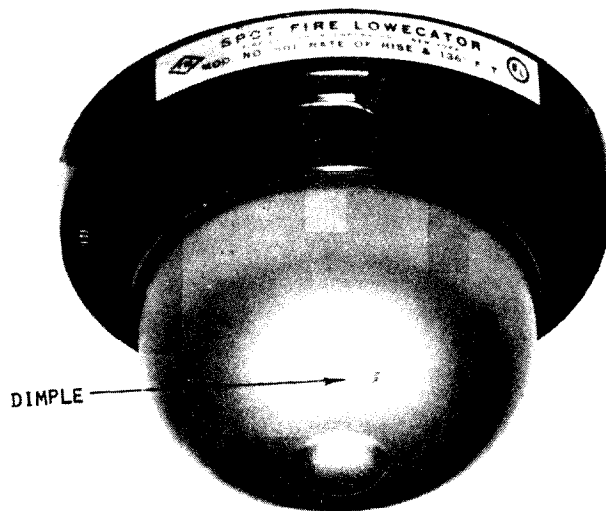


FIGURE 3-15
COMBINATION FIXED TEMPERATURE/
RATE OF RISE HEAT DETECTOR



FIGURE 3-16
RATE COMPENSATED HEAT DETECTOR

- Rate of Rise Detectors. These detectors are found in the styles of Figures 3-13 and 3-15. Rate of rise detectors cause an alarm whenever the rate of temperature rise exceeds about 15°F per minute. Heating causes an increase in air pressure inside the detector. A slow increase in pressure bleeds-off through a

breather valve while a fast increase operates a bellows type diaphragm which operates the alarm contact, causing a signal. The detectors automatically reset after actuation and are reusable. Actuation is not visually indicated.

- Combination Detectors. These detectors are found in the styles of Figures 3-13 and 3-15. The combination detector contains both fixed temperature and rate of rise elements. If either element actuates, an alarm results. The fixed temperature element is visible and actuates only once. If the fixed temperature element actuates, the whole device must be replaced. The rate of rise element automatically resets and is reusable.
- Thermopile Detectors. The detectors use one set of series connected thermocouples, exposed to the environment through a transparent dome, and a similar set is shielded inside the base of the detecting element. If the detector is exposed to fire, the exposed set experiences an increase in temperature greater than that experienced by the unexposed set. The thermocouples, each composed of a welded junction of dissimilar metals, generate a small voltage dependent on their temperature. The hot, exposed thermocouples generate a higher voltage than the cooler, unexposed ones. When the voltage difference is great enough to cause an alarm, the heat detector control unit is activated. This type of detector acts as a rate of rise heat detector which can effectively protect large areas. Thermopile detectors automatically reset and are reusable.
- Thermistor Detectors. Thermistor type heat detectors use semiconductor material with a high negative coefficient of resistance. The resistance of the thermistor drops rapidly to a low value as its temperature increases and causes an alarm signal. This device automatically resets and is reusable. In its simplest form, the thermistor acts as a fixed temperature heat detector, though it may be found as a rate of rise detector using additional circuitry.
- Testing and Maintenance of Spot Type Heat Detectors. Spot type heat actuated detectors should be inspected monthly for physical damage and for painting. Painting slows or inhibits the response of devices to a fire. Replace any painted or damaged devices. During the monthly inspection, note any new enclosed spaces and add detectors if needed.

Test restorable heat detectors semiannually on a rotation schedule to insure that all devices will be tested over a 5-year period. During the semiannual tests, select at least one detector from each initiating circuit (zone) for testing. Nonreusable detectors with replaceable elements can be tested by removing and reinstalling the element. Test and replace all nonreusable detectors in a 5-year period after the 15th year. The testing provides training opportunities and improves the alarm system reliability: Keep accurate records of devices tested, their locations; and the rotation scheme so no devices are overlooked and so that others can do the testing.

Spot type heat actuated detectors can be tested using various sources of heat. If the detector is located in a hazardous area which may contain explosive fumes or other highly flammable materials, use an explosion-proof lamp. For nonhazardous areas, the heat source may be an infrared lamp, a hair dryer, or a hot air gun. Be careful to avoid heat or smoke damage to reusable detectors and to the surroundings. Test both the rate of rise and fixed temperature features in combination detectors which have a nonreusable fixed temperature element. First use a higher heat level for a short period and direct it away from the fusible fixed temperature element, if possible, to actuate only the rate of rise element. When an alarm occurs, allow Cooling and reset and then apply more gradual heat to actuate the fixed temperature element.

- Troubleshooting. See Sections 3.5.3.3 through 3.5.3.6 for troubleshooting of initiating circuit problems. Troubleshoot special circuits for thermopile or thermistor type detectors according to the detector manufacturer's instructions. If you do not obtain a proper signal during a test, determine if the problem relates to a circuit, a device, or a control unit. If other nearby devices in the same circuit work properly, the problem is probably related to the device.

Be careful not to test the detector in a way that will destroy the element. A non-restorable detector cannot actually be heat tested as a practical matter, but proper circuit function can be tested by short circuiting detector terminals with a screwdriver for normally open detectors, by removing and reinstalling the replaceable element for replaceable element detectors, or by removing a wire for normally closed detectors. If there is still a problem, check for loose or intermittent connections at terminals, Tug lightly on wires at the terminals to check for firm connections and the absence of any broken wires.

If it appears that the device is the cause of the problem, follow these rules:

1. If the device caused no alarm during a routine test, first make sure that the alarm was not deactivated by the alarm silence switch.
2. If a heat detector causes a continuous alarm at the control unit, remove the detector from the initiating circuit and reestablish the initiating circuit temporarily to see if the alarm condition can be restored to normal. If so, replace the detector and reconnect wires permanently.
3. If a detector is defective but no replacement is immediately available, remove the detector, reestablish the initiating circuit, and tag the location with information on the type and rating of the replacement required. Obtain and install the replacement as promptly as possible. After installing a new device, check the wiring connections.

3.6.2.2 Line Type Heat-Actuated Detectors. A line type heat detector senses temperature conditions along a line. The line type detector may be formed into a rectangle or some other shape to suit the area protected.

- Line Type Fixed Temperature Detector. One type of line type fixed temperature detector uses a pair of steel wires in a normally open circuit. The conductive wires are insulated from each other by a thermoplastic material with a known melting temperature. The wires are under tension and are held together by a braided sheath or other suitable covering to prevent mechanical damage. At the design temperature, the insulation melts, contact is made between the two steel wires, and an alarm signal is initiated. The melted section of cable must be replaced after an alarm.
- Line Type Rate of Rise Detector. A line type rate of rise detector consists of a continuous loop of metal tubing (usually copper) , without branches, attached to the ceiling of the protected area. There may be as much as 1,000 feet of tubing in the loop, both ends terminating in an air chamber in the detector unit. If a section of tubing experiences a rapid increase in temperature, the air in the tubing expands faster than it can be exhausted through an adjustable vent in the detector unit. Bellows type diaphragms in the detector unit expand, making an electrical contact which causes an alarm. The bellows diaphragms are sometimes arranged to mechanically actuate a coded transmitter in a coded alarm system.

In a line detector system which must protect a small space, among other larger protected spaces, it may be difficult to expose enough tubing to a possible fire in the small space to obtain sensitivity. In that case a coil of tubing, called a "rosette," is inserted in the line where increased sensitivity is needed.

- Line Type Thermistor Detector. A line type thermistor heat detector has a stainless steel capillary tube containing a coaxial center conductor separated from the tube wall by a temperature sensitive semiconductor. Under normal conditions, a current, less than that required for an alarm, flows in the circuit. As the temperature rises the resistance of the semiconductor decreases, allowing more current to flow and causing an alarm. This type of detector acts as a fixed temperature detector and is reusable.
- Testing and Maintenance of Line Type Heat Detectors. Line type heat detectors should be inspected monthly for physical damage and for painting. Painting slows or inhibits detector response to a fire. Cable with heavy layers of paint should be replaced.

Check for any changes in partitions or floor plan since detector installation and rearrange or add detectors or rosettes as needed. Test the reusable line type detectors semiannually, using a heat source such as a 300 to 400 watt infrared lamp. Test rosettes in a rate of rise tubing loop on a rotation schedule so all rosettes in a system are tested at least every five

years. A rosette in an average size rate of rise system should respond to a 375-watt infrared lamp held 5 inches from it in less than 1 minute. Longer exposure may discolor nearby painted surfaces. Additional tests to confirm the integrity of the tubing (no leaks or pinched tubing) and proper adjustment of breather vents should be done semiannually and problems promptly corrected in accordance with the manufacturer's instructions.

Nonreusable line type fixed temperature detectors are usually provided with a test switch at the end of the sensing cable. Operating the switch causes an alarm. Test the detector with the test switch semiannually and replace any damaged or faulty cable sections promptly in accordance with the manufacturer's instructions. Measure and record loop resistance semiannually. Check the line type thermistor detector semiannually with an infrared lamp heat source as with other reusable line type detectors. Longer exposure may discolor nearby painted surfaces. Vary the location along the tube for each test. Measure and record detector resistance semiannually and correct problems, such as damaged tubing, promptly in accordance with the manufacturer's instructions.

- Troubleshooting. Line type heat actuated detectors are somewhat specialized with different characteristics depending on the manufacturer. Most troubleshooting should be performed using the manufacturer's test kit and instructions.

Line Type Fixed Temperature Detectors. For troubleshooting purposes, this detector can be treated as either an unsupervised, Class B, or Class A initiating circuit, depending on the method of connecting the detector to the control unit. Noticeable changes in semiannual resistance readings should be checked unless there have been additions to the system. Replace damaged cable sections in accordance with the manufacturer's instructions.

Line Type Rate of Rise Detector. If a pneumatic tubing detector loop has no rosettes, it is usually advisable to add at least one rosette to simplify testing, unless the total length of tubing in the loop is small. If testing fails to produce an alarm, there may be pinhole air leaks in the system or the air vent at the main air chamber may bleed off air too rapidly. Check for air leaks, using the manufacturer's test kit and instructions. If there are no leaks, adjust the vent to bleed off air slower to increase sensitivity. Replace tubing sections with leaks or crimps as the manufacturer recommends, and retest. If false alarms occur with rapid increases in temperature due to weather, which are not corrected by vent adjustment, look for an obstructed vent. Clean the vent as the manufacturer recommends, if it is obstructed, and test.

Line Type Thermistor Heat Detector. If a section of thermistor tubing is pinched, the other tube may be short circuited to the inner coaxial conductor causing a continuous alarm condition. Examine the entire length of the tubing for damage if this occurs. Radical changes in the semiannual resistance measurements should be checked. Repair or replace damaged sections in accordance with the manufacturer's instructions. Perform other tests, following the manufacturer's instructions. After repairs, repeat the tests.

3.6.3 Smoke Actuated Detectors. Smoke actuated detectors are ionization or photoelectric type and spot, beam, or duct design.

3.6.3.1 Spot Type Photoelectric Smoke Detectors. Most modern spot type photoelectric detectors use the light reflection principle to detect smoke. The diagram in Figure 3-17 shows a typical arrangement of functional parts. A pulsed light beam from a light emitting diode (LED) with its associated optics is projected across the interior of a blackened chamber which may contain smoke to be detected. A photocell, with its optics, looks toward the projected beam along a line perpendicular to the beam. When smoke enters the chamber, the smoke particles reflect a small portion of the light beam toward the photocell, which provides a voltage to be amplified and causes an alarm. The light source may be monitored ahead of the smoke chamber and regulated to prevent variation of the light intensity from causing erratic detector behavior.

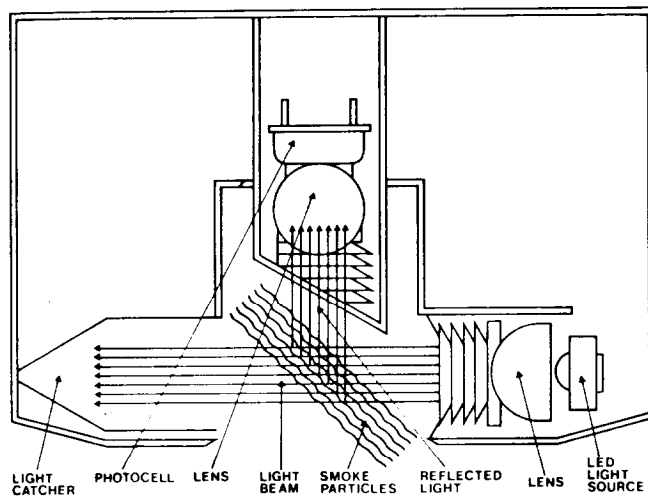


FIGURE 3-17
TYPICAL ARRANGEMENT OF PHOTOELECTRIC SMOKE DETECTOR COMPONENTS

3.6.3.2 Spot Type Ionization Smoke Detector. A small amount of radioactive material ionizes the air inside a chamber, which is open to the ambient air. A measured, small electrical current is allowed to flow through the ionized air. The small, solid particle products of combustion which enter the chamber as a result of fire interfere with the normal movement of ions (current) and, when the current drops low enough, an alarm results. A two position switch to control sensitivity may be provided. A detector of this type is shown in Figure 3-18.

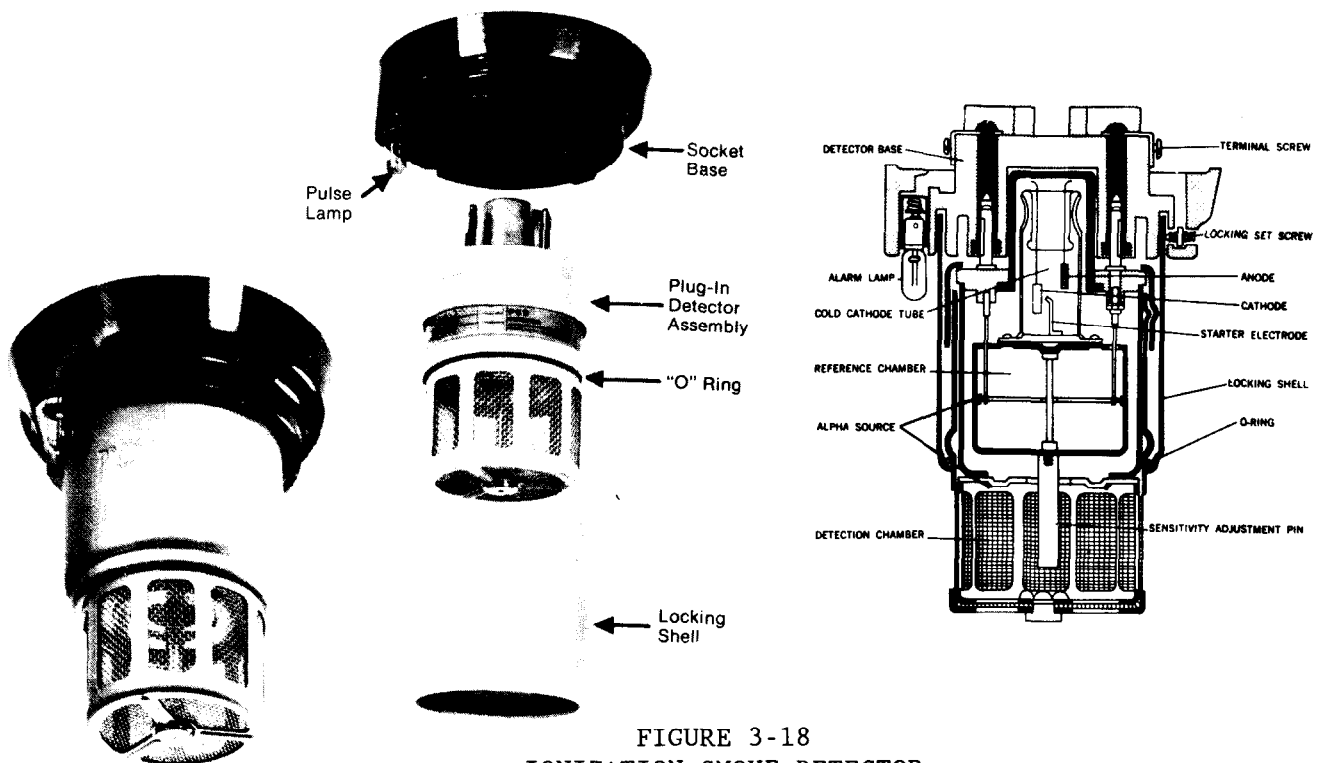


FIGURE 3-18
IONIZATION SMOKE DETECTOR

Modern ionization detectors have additional means to improve stability and immunity to atmospheric effects. A reference chamber is vented to the outside only through a small orifice which does not readily admit smoke particles. Temperature, humidity, and pressure changes are sensed by both the reference chamber and the smoke chamber, and their effects on alarm sensitivity are eliminated by electronic balancing.

3.6.3.3 Beam Type Photoelectric Smoke Detector. The projected beam type photoelectric smoke detector uses a light source and a light sensing photocell, similar to the spot type photoelectric detector. In the beam type detector, the light source and photocell are mounted near the ceiling on opposite sides of the protected room. When smoke obscures the light below a predetermined value at the photocell, an alarm results. Sometimes the light path between the source and the photocell is shielded to prevent light blockage by solid objects. Mirrors may be used to increase the light beam path length and protect larger areas or to give more effective protection of an area. Modern beam detectors may use modulated infra red beams instead of visible light beams.

3.6.3.4 Duct Type Photoelectric Smoke Detector. The duct type detector operates on the same principle and has the same internal construction as spot type photoelectric detectors. The major difference between duct and spot type detectors is the method of moving the smoke into the detection chamber. The spot type detector relies on convection of air in a room. The duct type detector is intended for detecting smoke in an air handling system. It is mounted directly on the outside of an air duct or nearby with a sampling tube extending about three quarters of the way across the inside of the duct. The sampling tube has holes in it, directed upstream, for normal airflow in the duct to produce a cross sectional sample of air from the duct. The air flows into the smoke detection chamber, mounted on the outside of the duct, and back into the duct through a return tube, having a hole or holes directed downstream. As long as there is airflow in the duct, a portion of that air

continuously flows through the detection chamber. A gasket seal prevents ducted or ambient air from entering the smoke detecting chamber directly and diluting the air sample taken from inside the duct.

The duct type detector may have a key operated test/indicator station. The duct detector may also have more and heavier duty alarm output contacts than the spot type detector because the duct type detector is frequently used for direct control of higher current electrical devices, such as HVAC fans and dampers, or fire door releases, rather than for an alarm system, which has lower current requirements.

3.6.3.5 Duct Type Ionization Smoke Detector. The duct type ionization detector operates on the same principle and has the same internal construction described earlier for spot type ionization detectors. The major difference between the duct and spot type detectors is the method of moving the smoke into the detection chamber. The spot type detector relies on convection of air in a room. The duct type detector is intended for detecting smoke in an air handling system and is mounted directly on the outside of an air duct or nearby with sampling and return tubes extending completely across the duct. Figure 3-19 shows a typical detector with sampling and return tubes.

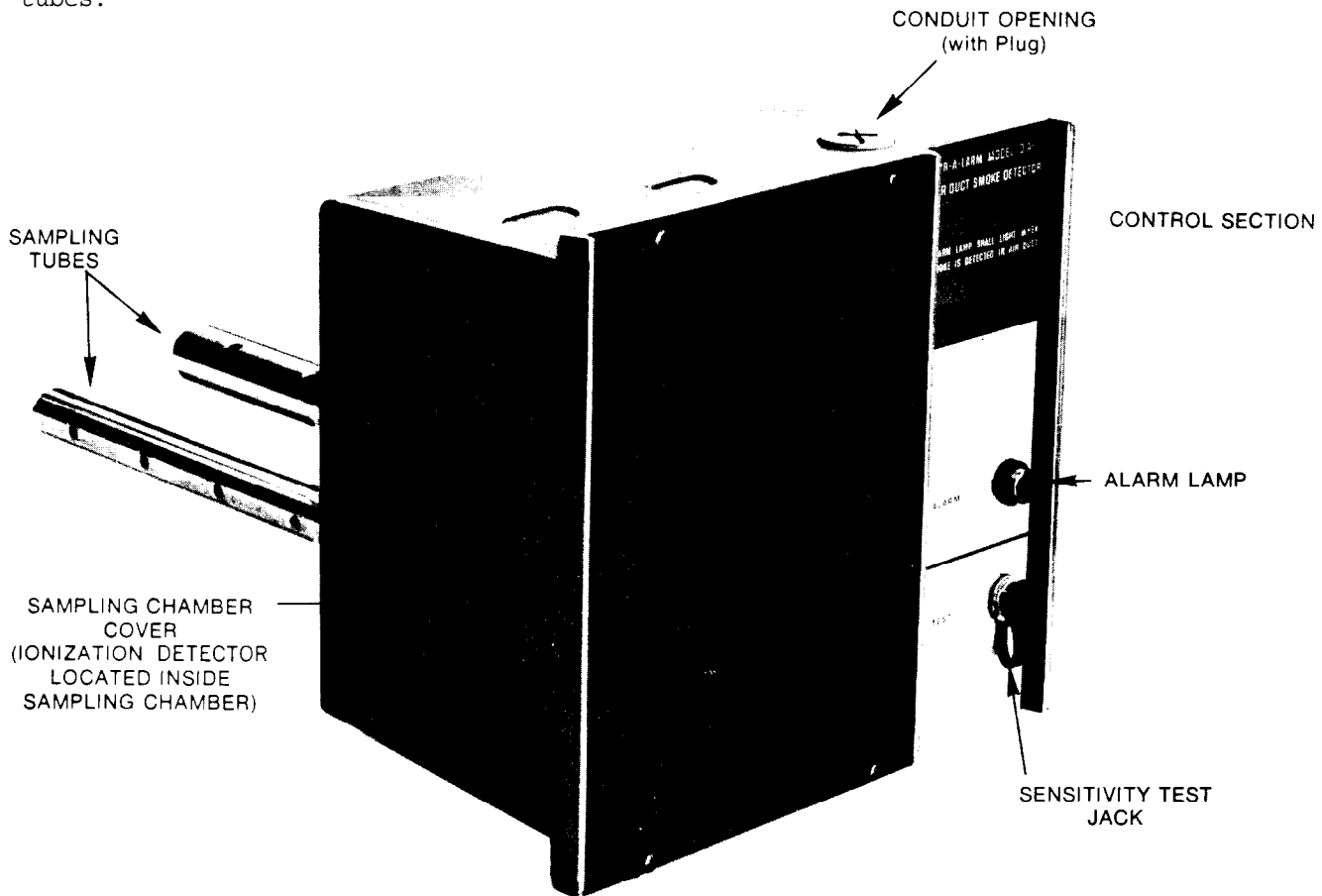


FIGURE 3-19
DUCT TYPE IONIZATION SMOKE DETECTOR

Wide ducts which require long tubes require tube support with brackets or holes in the duct wall. The outer ends of the tubes are sealed with rubber stoppers or similar means. The inlet holes in the sampling tube are directed into the airstream; the outlet holes in the return tube are either directed

downstream, perpendicular to the airflow, or adjusted for a particular airflow through the detector or pressure difference between the sampling and return tubes, depending on the manufacturer's installation instructions. Normal airflow velocity is usually 500 feet per minute; the normal pressure difference between sampling and return tubes is usually one inch of water.

3.6.3.6 Testing and Maintenance. Smoke actuated detectors should be inspected monthly for physical damage and for painting. Remove or mask the detectors when painting because paint may prevent good electrical contact at connectors and proper mechanical fit.

Replace spot type smoke detectors which show any of the following during the monthly inspection: corrosion, paint, paint removal (indicating previous painting), physical damage, exposure to grease or other deposits, corrosive atmospheres, overvoltage surges or lightning damage. In many cases, removed detectors may be repairable by the manufacturer. Before testing detectors which are connected to auxiliary functions, such as release of a fire extinguishing agent, release of fire doors, or fan shutdown, disconnect or bypass the auxiliary functions (unless the test is specifically intended to test these features). Notify the fire department and persons where the audible signals can be heard.

All types of smoke detectors should be tested semi-annually. A calibration check should be performed after the first year of installation. If the sensitivity has not changed since installation, then a calibration check is needed only every other year.

- Spot Type Photoelectric Smoke Detector. Most detectors of this type have a built-in test feature. In some models, a test light source actuated by a key operated test switch or by holding a magnet near a built-in reed switch causes light to reach the normally dark, smoke sensing, photocell in a quantity approximating the light of an average smoke test. In other detector models, the smoke simulation is performed by inserting a reflective surface into the smoke chamber so that actual source light is reflected to the smoke sensing photocell. Test at least one detector in each initiating circuit (zone) monthly. Follow a rotation schedule so that all detectors are tested semiannually.

Test failures or false alarms may result from an excessive accumulation of dust or dirt caused by an adverse environment. Blow out the smoke chambers with low pressure air. (Partial disassembly of the detector and disconnection of detector power, following the manufacturer's instructions, are required.) Since the photocell is normally dark, disassemble and clean in a darkened area to minimize the photocell recovery time after cleaning before repowering the detector. Allow approximately 30 minutes for recovery after reassembly of the detector before reconnecting power. Disconnecting power by unplugging one detector may also disconnect power from the other detectors further from the power source. Local fire authorities may require special precautions during any extended testing period. Special equipment which may be required for cleaning consists of a low pressure air source for blowing out dust and a suction cup for chamber cover removal.

If the cleaning does not correct the false alarms or failure to alarm, return the detector to the manufacturer for repair.

- Spot Type Ionization Smoke Detector. Test at least one detector in each initiating circuit (zone) monthly. Follow a rotation schedule so all spot type ionization detectors are tested semiannually in accordance with the manufacturer's instructions. Any detectors which produce false alarms between semiannual tests or do not test satisfactorily should be checked for sensitivity, following the manufacturer's instructions and using test equipment available from the manufacturer or other sources. An aerosol synthetic smoke is available from some manufacturers for testing their detectors.

Unsatisfactory tests or erratic operation may indicate a need to remove accumulated dust or dirt. The frequency of cleaning should be based on results of regular tests and local conditions. Clean, check, and test operation and sensitivity following the manufacturer's instructions. For loose dust deposits, blow the area with low pressure air after removing a protective cover. For more stubborn deposits, disassemble and clean using a liquid recommended by the manufacturer. Recheck sensitivity and adjust if necessary after cleaning and thorough drying.

Some smoke detectors of this type produce an electrical shock which may not be severe enough to cause injury directly but could cause a fall from a ladder. Some manufacturers, because of such possible injury to personnel or damage to the detectors, do not recommend servicing by anyone other than factory trained personnel. The customer service department of most manufacturers can give advice on the telephone for specific problems. Be prepared to give the equipment model number and other pertinent information.

- Beam Type Photoelectric Smoke Detector. Check each detector semiannually. Usually simulate smoke by holding pieces of clear filter material furnished with the detector, in front of the lens. For instance, one thickness should not cause an alarm while three thicknesses should cause an alarm. Check the manufacturer's instructions to be sure this method is appropriate.

The beam type photoelectric smoke detector is probably more rugged than the other detectors discussed. The most frequent problems are burned out light sources and dirt or paint on lenses and filters which can cause false alarms. These problems should be discovered during monthly inspections and corrected promptly. Clean the lenses semiannually just before the regular operating test. Disconnect power to prevent alarms during lens cleaning, and wipe the sensor lens, any filters or mirrors used, and the projector lamp surface with a soft damp cloth.

Check the light beam to be sure it is directly centered on the sensor unit after cleaning. If necessary, remove filters and align the projector lamp, using adjustment screws provided on the projector unit. If mirrors are used, the alignment process is more difficult, so be careful during cleaning not to disturb their adjustment. Reassemble all removed parts before testing.

- Duct Type Smoke Detector. Duct type smoke detectors usually are tested with simulation type tests, using a key operated test switch at the detector or at a remote test/indicator location, if installed. Frequently, reset of a detector requires

momentary removal of power, either by using the key operated test switch or a switch at a central control panel. In testing duct mounted detectors, the length of time to activate each detector will vary. A typical response time is 10 seconds, but some detectors may require 30 seconds or more to activate.

Check the manufacturer's instructions before doing any cleaning, checking, operation or adjustment. Establish a routine cleaning schedule, based on local dust, dirt and HVAC filter conditions. Start with annual cleaning of the smoke chamber, sampling tubes and holes and increase or decrease the frequency, depending on performance results. A low pressure air hose should be adequate for most cleaning.

Refer to earlier paragraphs on spot type photoelectric and ionization smoke detectors for additional detail to apply to the respective duct type smoke detectors.

3.6.3.7 Troubleshooting.

- Photoelectric Smoke Detector. Photoelectric detectors are usually arranged to give a trouble signal for light source failure. Beam type smoke detectors with incandescent light sources require more frequent light source replacement than LEDs. Base personnel can replace lamps, following the manufacturer's instructions. Spot type detectors with LED light sources should be returned to the manufacturer for repair.

False or continuous alarms usually indicate that cleaning is needed. Continued unsatisfactory results after cleaning indicate that factory repair is necessary. Keep spare devices on hand for immediate replacement. Return failed units to the manufacturer promptly.

- Ionization Smoke Detector. False, continuous or erratic alarms or failure of ionization detectors to actuate after the factory recommended routine inspection and cleaning have been performed indicate that factory repair or repair by a factory trained technician is necessary. Schooling and test equipment are available from some manufacturers for training and assisting installers and service personnel. Defective devices should be returned to the factory.

3.6.4 Flame Actuated Detectors. Flame actuated detectors are optical devices which "look at" the protected area. They generally react faster to a fire than nonoptical devices. Because of their quick reaction, flame actuated detectors may be used where the anticipated fire is expected to develop quickly as is the case with fires involving flammable liquids, explosions, etc. Flame detectors are referred to as line-of-sight detectors since they cannot detect fires which are around corners or otherwise obstructed from view.

3.6.4.1 Infrared Flame Detectors. Infrared (IR) flame detectors respond directly to the IR, modulated (flickering at 5 to 30 cycles per second) radiation from flames. To minimize responses to nonfire sources of radiation, the sensor design usually incorporates a delayed response, selectable in the range of 3 to 30 seconds. Thus, alarms are caused only by sustained, flickering sources of IR radiation. Figure 3-20 shows two typical IR flame detectors.

The IR flame detector is ineffective for smoldering or incipient fires. It is used where possible fires would develop quickly (fuels such as combustible gases and liquids or loose cotton fiber) and it is capable of protecting a large area, if mounted high on a ceiling or wall (30 to 50 feet).

The sensitivity of IR detectors to a fire is affected by the distance of the device from the fire. For example, if the distance is doubled, the required fire for detection must be four times as large. In order to maintain immunity to possible nonfire sources of alarms, longer response delays (10 to 30 seconds) are usually selected for low ceiling (8 feet) mounting. Shorter delays, in the range 3 to 10 seconds, are used when detectors are mounted on higher ceilings. For high hazard areas, the detector can be mounted on a low ceiling and a low delay setting used to obtain sensitivity and fast response. Shields to eliminate possible false alarm sources from the field of view of the detector are sometimes used, especially in a high sensitivity application of the device.



FIGURE 3-20
INFRARED FLAME DETECTORS

Some detector models designed for fast response do not have the "flicker" discrimination feature, but instead have two sensors with different spectral responses. Such detectors are referred to as "dual band" detectors. These sensors are used to distinguish between an actual fire and other sources of IR radiation, such as heated objects and sunlight.

Glowing ember detectors are nondiscriminating and fast acting. Ambient light levels must be maintained below 20 foot candles. Placement and shielding are important for this type to avoid false alarms due to incandescent lamps and sunlight.



The detector and circuitry may be in a single housing or in separate housings. They act together as a normally open switch which becomes momentarily closed, causing an alarm, when UV radiation enters the detector viewing window. Response time is typically less than 25 msec for an intense UV source. Some models have a built-in short time delay (3 seconds, nominal) to minimize responses to lightning and other momentary events.

3-57

A test feature designed into some detectors allows for checking the optical integrity of the device. A small UV source inside the detector housing is shielded from directly illuminating the sensor. Local or remote operation of a test switch deactivates alarm circuits and illuminates the test lamp. Its rays pass out through the viewing window, strike a mirrored surface at the edge of the opening, and return through the front window to the sensor. Detector response to the test indicates that the window is clean and that the sensor and electronic circuits are operational.

The UV detector is capable of use in explosive atmospheres and some models have swivel mounts for directing them at specific hazards. Various models have angular fields of view ranging from 90 to 180 degrees. Sensitivity is usually factory set for the application.

3.6.4.3-Combination Ultraviolet-Infrared Flame Detectors. A combination ultraviolet infrared (UV/IR) detector is able to discriminate against non-fire related sources of radiation such as welding, lightning and heated objects. The detector discriminates by sensing very specific wavelengths in both the UV and the IR range and electronically processing the signals from the sensors. The detector uses two separate sensors and sensing circuits. The two sensing circuits operate independently, each giving an output of conditioned pulses, the frequency of which is proportional to the intensity of the radiation sensed. The two outputs are compared and if the ratio falls within the specified fire signature limits, a single fire event is declared and entered into the Fire Event Register. Repeated comparison continues until the present number of fire events have occurred, at which time a fire is declared and reported. If the specified fire signature ratio of UV/IR is not met, a separate non-fire related UV or IR event is reported, virtually eliminating unacceptable false fire reports from other sources.

3.6.4.4 Testing and Maintenance. Flame actuated detectors should be inspected monthly for physical damage, accumulation of deposits and paint on the lens. A spot of paint on a lens can block the detector's view of a critical area of the protected space. Remove or protect the detectors when painting.

- Infrared Detectors. In Figure 3-20, the dark spot or dome at the bottom center of each infrared device is the lens. Detector lenses must be kept clean to insure the earliest possible detection of a fire. Test at least one detector in each initiating circuit (zone) monthly. Follow a rotation schedule so that all detectors are tested semiannually.

A small soldering iron, held 6 inches in front of a glowing ember type detector, can serve as a heat source for testing. A 250-watt infrared heat lamp several feet from the detector can serve as a flame substitute in testing an infrared flame detector. Be sure that auxiliary functions of the flame detection system are deactivated before testing unless these features are intentionally being tested. Inform the fire department and persons who would hear the alarm.

False alarms or failure to detect during a test may be from environmental factors or aiming of the detector. During the monthly inspection, check that detectors are not blocked and that lenses are shielded from direct rays of the sun and other normally occurring infrared sources.

If a detector has a clean lens but fails an operating test, make adjustments and/or other field maintenance, following the manufacturer's instructions. Obtain field service by a factory trained technician or return the equipment to the manufacturer for repair.

- Ultraviolet Detectors. Keep W detector lenses totally clean. A gradual buildup of contaminants frequently found in high hazard spaces (oil, gasoline, petrochemicals, salt, and dust) blocks W radiation. A layer thin enough to be undetectable to the human eye can cause a UV detector to be completely blind. Clean lenses according to the manufacturer's instructions. Test models of UV detectors with the built-in optical integrity test feature during the monthly inspection. Clean and retest detectors which fail the test.

False alarms and failure during a test may be related to environmental factors or aiming of the detector. During the monthly inspection, check that detectors are aimed to protect the intended areas, that detectors are not blocked, and that lenses are shielded from direct rays of the sun and other normally occurring UV sources, such as welding equipment.

Monthly perform an operational test on at least one detector in each initiating circuit (zone). Follow a rotation schedule so all detectors are tested semiannually. UV sources for test purposes are available from some UV detector manufacturers. Be sure that auxiliary functions of the detection system are deactivated before testing unless these features are to be tested. Notify the fire department and persons who would hear the signals.

If a detector has a clean lens but fails an operational test, make adjustments and/or other field maintenance, following the manufacturer's instructions. Obtain field service by a factory trained technician or return defective equipment to the manufacturer for repair.

- Combination UV/IR Detectors. Maintenance requirements for combination UV/IR detectors are the same as those for UV detectors and IR detectors.

3.6.4.5 Troubleshooting. Erratic alarms and failure to detect flames or simulated flames during tests are the most frequent problems of flame detectors. A failure to detect is usually caused by an accumulation of oil, paint, or dust deposits on a lens or by an object blocking the detector's view of the flame. Clean the lens as soon as possible when a problem occurs and aim the detector so it has an unobstructed view of the area. High speed detectors, intended for use in low ambient light conditions, may become desensitized from overexposure to ambient light. Follow the manufacturer's recommendations in controlling ambient conditions.

Spurious or erratic alarms are caused by direct or indirect sources of infrared or ultraviolet rays which appear as a flame to the detector. Ember detecting infrared detectors may respond to incandescent lamps or to sunlight striking an object. Sunlight reflections from lakes, puddles, windows, venetian blinds, machinery, and passing cars and trains are examples of some reflective sources which may flicker like a flame and cause infrared alarm signals. Some direct light sources which may cause spurious infrared alarms are flickering neon signs or lamps and headlights on moving vehicles. These light sources should be shielded from the view of infrared detectors. The main sources of spurious alarms for ultraviolet detectors are welding and cutting operations within view of the detectors.

3.6.5 Sprinkler Waterflow Actuated Detectors. Sprinkler waterflow detectors are generally pressure actuated or vane actuated. Pressure switches are used on both wet and dry pipe sprinkler systems. Vane switches are widely used on wet pipe sprinkler systems. They cannot be used on dry pipe systems because the mechanical shock of the initial rush of water into the pipe could damage the vane and mechanism.

Dry pipe system alarms tend to be slow acting because it takes time to lose sufficient air through a fused sprinkler to trip the system. Various methods are used to speed up dry pipe systems. Wet pipe system alarms have a different problem. Fluctuating water pressure frequently causes flow into a sprinkler system, equalizing the sprinkler system pressure with the supply pressure. Such surges of water or of pressure cause spurious waterflow alarms if some method of slowing down the switch response to the surge is not used. Various retarding techniques are used, some associated with the waterflow detector and some with the sprinkler piping.

3.6.5.1 Pressure Increase Type Waterflow Detector. Numerous styles of this type of waterflow pressure switch are found in wet and dry pipe systems. (Figure 3-22 shows one style.) The usual arrangement for switch actuation includes a sealed accordion-like bellows which is assembled to a spring and linkage. The spring compression or tension controls the pressure setting of the switch and may be adjustable and/or factory set to the desired pressure. As water or air pressure in the bellows increases, it expands, providing motion against a spring. The linkage converts the bellows motion into the desired motion to actuate the electrical switch. If the pressure switch is used on a wet pipe system, it is usually mounted at the top of a retarding chamber, which reduces the speed of pressure buildup at the switch.

There are also waterflow pressure increase detectors which incorporate a pneumatic retarding mechanism within the detector housing. The retard time is adjustable to a maximum of 90 seconds with usual settings in the range 20 to 70 seconds. The retarded switch would be connected to the alarm port of a wet sprinkler system alarm check valve. The usual pressure settings for these switches are in the range of 8 to 15 psi.



FIGURE 3-22
PRESSURE INCREASE TYPE
WATERFLOW DETECTOR

3.6.5.2 Pressure Drop Type Waterflow Detector. Pressure drop type detectors can be used in wet pipe sprinkler systems equipped with a check valve (alarm check or swing check) which holds excess pressure on the system side of the check valve. These detectors are most frequently used where a water surge or hammer causes false alarms with other types of waterflow detectors.

The construction of pressure drop detectors is similar to that for pressure increase detectors. The switch for a pressure drop detector is arranged to actuate on a drop in pressure and there is no retarding mechanism or chamber. A typical switch of this type would be adjusted for some normal operating pressure in the range 50 to 130 psi. The alarm pressure would be adjustable to 10 to 20 psi below the normal pressure.

3.6.5.3 Vane Type Waterflow Detector. A vane type waterflow detector, used only in wet pipe sprinkler systems, is shown in Figure 3-23. The vane, a flexible, almost flat disc, is made of corrosion-resistant material. The detector is assembled to the pipe by drilling a hole in the wall of the sprinkler pipe. The vane is rolled-up to form a tube and inserted into the pipe through the hole. Once inside the pipe, the vane springs open, almost covering the inside cross section of the pipe. The whole detector assembly is clamped to the pipe with one or two U-bolts. Gaskets and other sealing devices prevent leakage of water out of the riser pipe and into the detector housing. Operation of a sprinkler causes water to flow in the system, moving the vane. A mechanical linkage connects the vane to an adjustable retarding device in the detector.

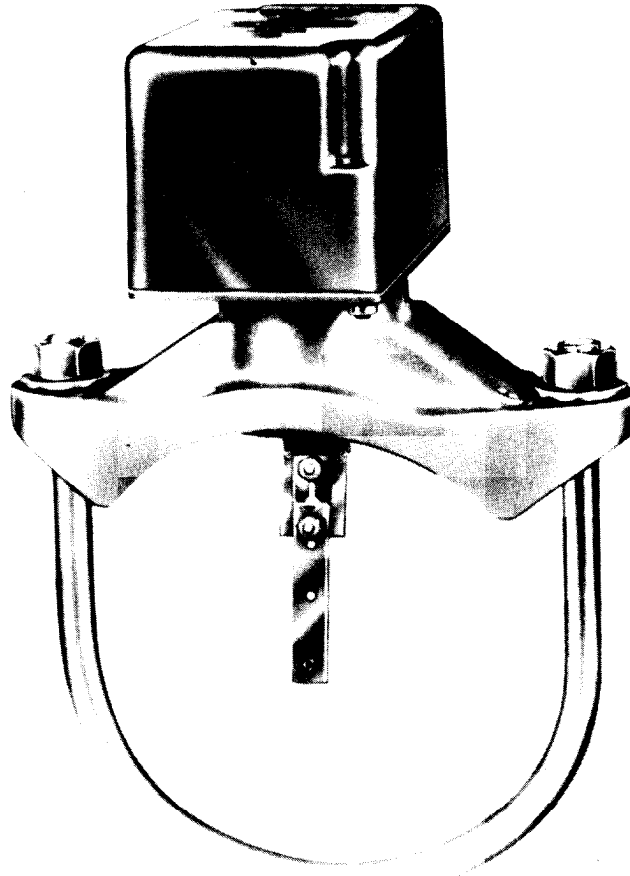


FIGURE 3-23
VANE TYPE WATERFLOW DETECTOR

The retarding device, which is usually a pneumatic dashpot, actuates the alarm switch or switches and/or signal transmitter, if the vane is still deflected at the end of the adjustable delay period. The retarding device prevents spurious alarms by delaying the mechanical actuation of the alarm switch(es) and/or transmitter to allow the vane and retarding mechanism to return to their normal positions after momentary water surges. The retarding device setting is usually in the range of 30 to 45 seconds, though the maximum setting may be as high as 90 seconds.

3.6.5.4 Pressure Pump/Pressure Drop Type Waterflow Detector. The pressure pump type waterflow detector is usually used in large sprinkler systems and those with inadequate water pressure to reliably operate one of the other types of waterflow detectors. Figure 3-24 shows a fixed pressure waterflow detector, with pump (another name for the same device). This type of detector has a pump, pump motor, and control unit as an integral unit, arranged for strap mounting to the sprinkler system riser. The device provides a waterflow alarm signal, a low system water pressure supervisory signal, and excess pressure in the system to prevent surges in the supply pressure from opening the alarm check valve and causing operation of the water motor gong or other alarm indicator.

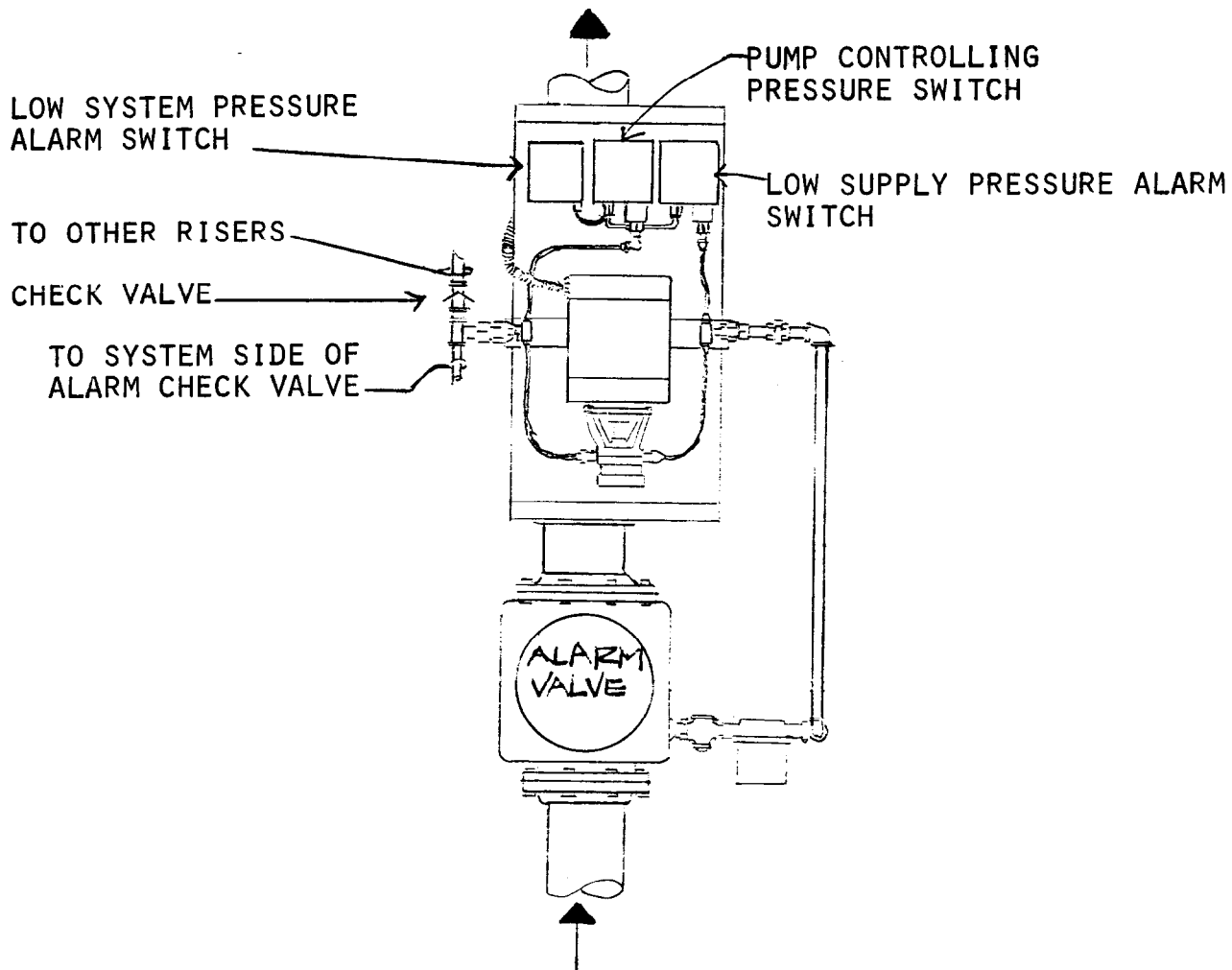


FIGURE 3-24
FIXED PRESSURE WATERFLOW DETECTOR WITH PUMP

A typical installed detector of this type is adjusted to maintain the system pressure at 25 to 50 psi above the supply pressure. A slow leak at the alarm check valve or anywhere in the system will cause the system pressure to drop slowly. When the pressure decreases to 2 psi below the preset value, a pressure switch closes, causing the pump to start pumping water from the supply side to the system side of the alarm check valve at a rate of about 1 gallon per minute. Note that this is too low a rate to maintain pressure if a sprinkler opens or to deliver a significant amount of water to a fire. If the total of system leaks amount to less than 1 gallon per minute, the pressure

switch opens and the pump stops when the preset pressure is reached. If the leak is greater than 1 gallon per minute, the system pressure continues to drop, even with the pump running. If the system pressure decreases to 4 psi below the preset value, a trouble pressure switch, which is closed at the normal pressure, opens to indicate that there is a system leak greater than 1 gallon per minute. This is a maintenance condition requiring repair. A trouble contact is also operated if the pump is switched off with the key-operated control switch. If the system water pressure continues to decrease to 6 psi below the preset value, an alarm pressure switch (open at the normally maintained pressure) closes, signaling a waterflow alarm. Some fixed pressure waterflow detectors of this type have an additional pump protection pressure switch which disconnects pump power when the supply pressure drops below about 14 psi. This additional switch prevents running the pump dry if the water supply is shut off or there is a break in the supply pipe.

3.6.5.5 Electronic Pressure Drop Waterflow Detector. The electronic pressure drop detector is often used in sprinkler systems which must maintain a high excess system pressure over supply pressure (resulting from fluctuations in supply pressure or use of an excess pressure pump) that would delay actuation of a vane type waterflow detector. It is normally mounted to the riser pipe with a flexible, rugged hose connection to the system side of the check valve for pressure sensing. Figure 3-25 shows a detector of this type with its cover open. The device requires a pressure drop of 0.3 to 1.3 psi continuing over a period of at least 3 seconds to signal an alarm. A pressure drop at a slower rate or of shorter duration causes no alarm. A slow pressure drop to 15 psi or less causes a trouble signal indicating that there is a system leak and low supply pressure. Pressure increases do not cause an alarm, but an overpressure condition (200 psi) causes a trouble signal. Trouble signals are also caused by opening the detector's metal cover, supply voltage outside the normal range, and an internal circuit failure that would interfere with proper functioning.

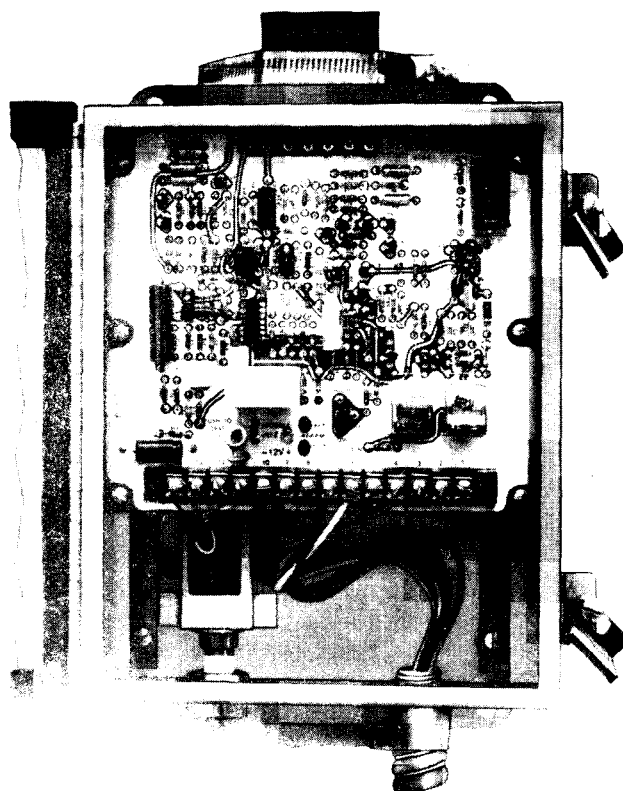


FIGURE 3-25
ELECTRONIC PRESSURE DROP
WATERFLOW DETECTOR

3.6.5.6 Testing and Maintenance. Waterflow actuated detectors should be inspected hi-monthly for physical damage and for paint on information plates and labels. Replace or repair damaged devices immediately. Clean or replace painted plates and labels. Correct other deficiencies promptly.

During the inspection, note any new additional waterflow alarms. Test some sprinkler system waterflow detectors each month. Follow a rotation schedule so that a group of buildings in a large installation is tested each month and a complete cycle of tests of all waterflow detectors for all buildings is completed quarterly. When detectors are connected to a base alarm system, tests should include checking for clearly identifiable signals received at the alarm headquarters.

- Wet Pipe Sprinkler System Waterflow Detectors. Test wet pipe sprinkler system waterflow devices by causing a flow of water equal to that from one sprinkler by opening the inspector's test valve fully. This valve is usually near the end of the sprinkler system on the opposite side of the building from the system riser. For sectional waterflow detectors, the inspector's test valve is usually on the opposite side of the section of the building from the riser. The inspector's test valve is left open to allow full flow until an alarm is indicated at the local control unit or, if connected to the base alarm system, until a clear alarm is received at the alarm headquarters. One person with radio or telephone communications at the test valve and one person at each alarm receiving location are usually needed for testing.

The delay between the start of full flow and receipt of the alarm signal should be between 15 to 90 seconds for retarded signals. Detectors which sense a pressure drop should respond in less than 15 seconds. If the alarm has not been received after water has been flowing for 3 minutes, stop the test and determine the cause of the problem (see Section 3.6.5.7, "Troubleshooting"). The test is sometimes continued longer as a troubleshooting method, but not as a matter of routine testing.

- Dry Pipe Sprinkler System Waterflow Detectors. Dry pipe sprinkler systems have an alarm test valve at the sprinkler riser in the trim piping which allows water from the supply side of the dry pipe valve to exert supply pressure on the pressure increase type waterflow detector. The alarm test valve is frequently a small lever type valve, but may be a globe valve. It should be permanently tagged as the "alarm test valve" to expedite future testing.

The regular trip test (Chapter 5) of a dry pipe sprinkler system to check the operating condition of the sprinkler system can also be used to test the waterflow detector and alarm system if the tests are coordinated. However, it is not practical to trip test the dry pipe valve for every alarm system test. Do not open the inspector's test valve at the end of a dry pipe sprinkler system for an alarm system test unless a trip test is desired.

3.6.5.7 Troubleshooting. The most frequent problem associated with waterflow detectors is a failure to receive an alarm signal within the allotted time. One method for troubleshooting is manual actuation of the waterflow detector to simulate the action produced by an actual waterflow. For detectors with a signal retarding device, this initiates the timing sequence. If the alarm signal is still not received within a reasonable time (less than 90 seconds), and the mechanical action of the retarding device and switch or transmitter is normal, the problem is a circuit problem. (See troubleshooting for circuit problems.) If the signal is properly received with manual actuation of the detector, the original problem may be associated

with the mounting of the detector (misalignment causing vane rubbing on the inside of the pipe) or with a defective sensing element in the detector (defective bellows in a pressure switch). Correcting misalignment may require draining the system, removing the waterflow vane switch, and redrilling the hole on an axis perpendicular to the pipe axis. If a pressure switch bellows is defective, usually the complete pressure switch must be replaced.

Defective retarding mechanisms usually can be replaced as a unit. Symptoms of defective retarding mechanisms are: failure of retard time to change smoothly with changing adjustment, failure of retarding mechanism to cause any delay, and failure of the mechanism to cause or allow switch or transmitter actuation. If these symptoms occur, the retarding mechanism should be replaced and the defective unit returned for repair.

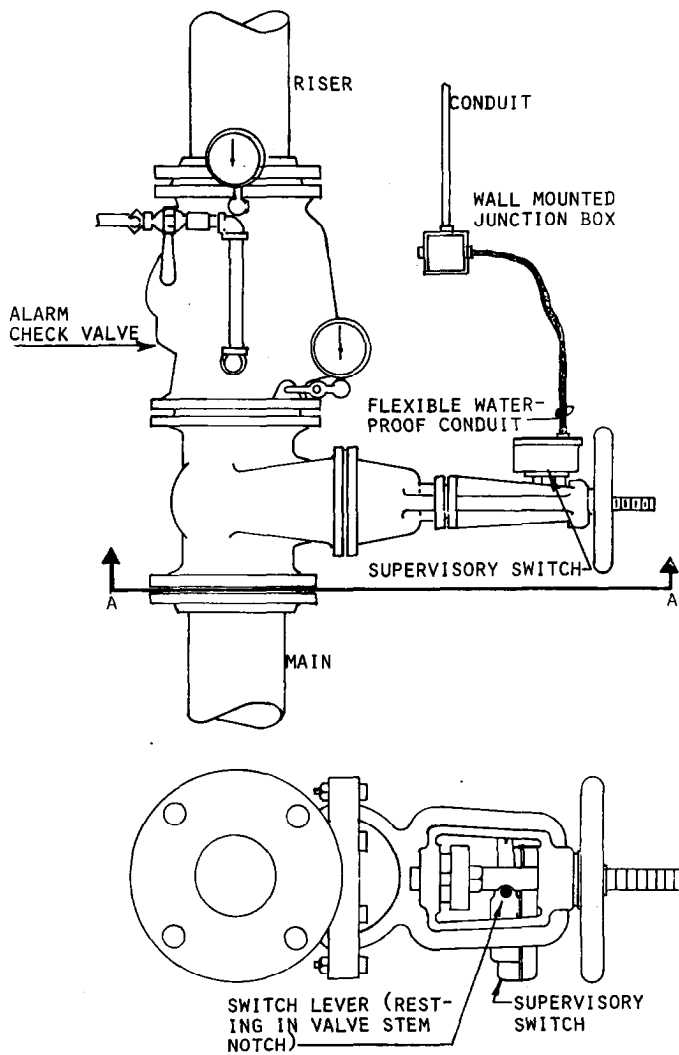
Individual alarm switches in waterflow detectors can usually be removed and replaced. Investigate a trouble indication on a waterflow detector zone as a detector related problem before troubleshooting the initiating circuit. Frequently, removing the detector cover operates a trouble indicating switch. Electronic waterflow detectors also cause trouble indications for other abnormal conditions, such as pressure or supply voltage outside their normal ranges.

3.7 SUPERVISORY ALARM INITIATING DEVICES. Supervisory alarm initiating devices cause a signal at the supervisory control unit and/or remote receiver when an abnormal fire protection system condition occurs.

3.7.1 Valve Position Supervisory Devices. In general, supervised valves are never closed unless a sprinkler system or section of it requires maintenance. These valves control the main flow of water to a system or section of a system. Valves which control waterflow to a waterflow detector or valves in a sprinkler header room or fire pump room which are normally closed may also be supervised. Supervisory devices for normally open valves cause a supervisory signal when the valve is closed no more than two turns or 20% of its total travel. Supervisory devices for normally closed valves cause a supervisory signal when the valve is opened no more than two turns or 20% of its total travel.

3.7.1.1 Outside Screw and Yoke (OS&Y) Valve Position Indicator. OS&Y valves are frequently supervised. Figures 2-13 and 2-14 show two typical OS&Y valve supervisory devices. Figure 3-26 depicts a typical OS&Y valve with supervisory switch in place. The switch and its housing are firmly attached to the valve yoke. The spring loaded switch operating lever or plunger rests in a smoothly tapered notch in the valve stem. When the valve is operated, the stem moves toward the pipe (closing) or away from the pipe (opening). As the stem moves, the switch lever or plunger moves up the incline at the edge of the notch and the switch is actuated before the lever or plunger is out of the notch. Switch actuation causes a supervisory signal at the control unit and/or remote receiver.

3.7.1.2 Post Indicator Valve (PIV) Position Indicator. Figure 3-27 shows a PIV position indicating switch mounted on the PIV. A PIV is usually located outside the building and a length of underground conduit and cable connects the switch with the building supervisory system.



SECTION A-A

FIGURE 3-26
OS&Y VALVE POSITION SUPERVISORY
SWITCH INSTALLATION

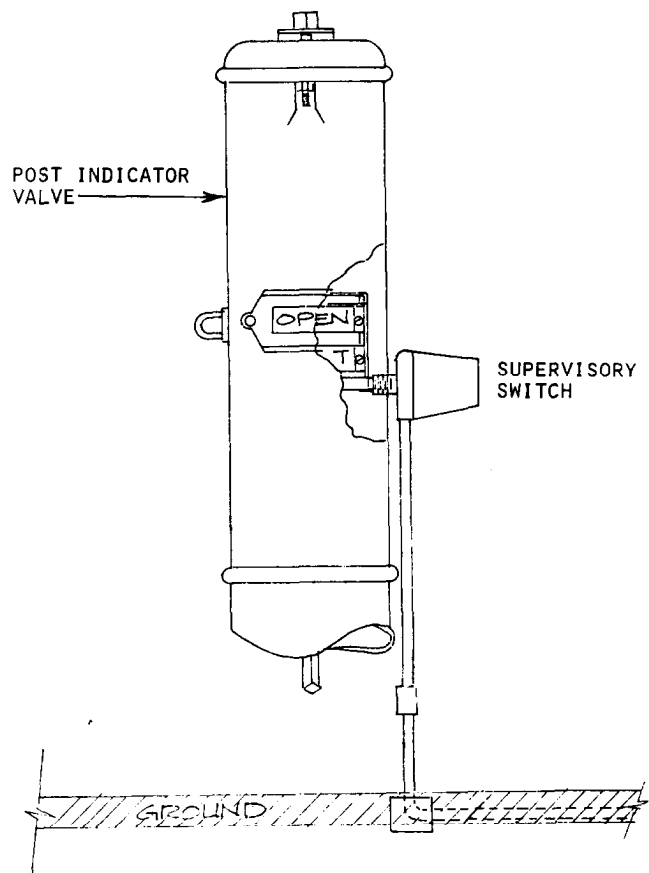


FIGURE 3-27
PIV VALVE POSITION SUPERVISORY
SWITCH INSTALLATION

A wall-mounted PIV has the valve handle and indicator switch extending outside the building with the valve itself inside the building. Like the OS&Y position indicator switch, the PIV position indicator switch is a lever operated switch. (Figure 2-17 shows an unmounted switch.)

The PIV spring loaded lever rests against the side of the open/shut indicator, called a target. As the valve is operated--using a special handle or wrench on the square operating nut at the end of the indicator post--the target moves. The switch lever follows that movement. The switch is adjusted to cause a supervisory signal before the operating nut has rotated two turns from the normal position or 20% of its full travel.

3.7.1.3 Butterfly Valve Position Indicator. A butterfly valve is sometimes used to control the supply of water to sprinkler systems. Figures 2-18 and 2-19 illustrate some frequently used types and methods of mounting position indicating switches on butterfly valves. The distinguishing feature of a butterfly valve that affects its supervision is that its moving parts are concealed in a housing. The supervisory device usually has a lever or plunger extending through an opening in the housing to sense valve operation.

3.7.1.4 Nonrising Stem Valve Position Indicator. Nonrising stem gate valves are installed underground and controlled from the surface by a wrench or key. If it is included in a supervisory signaling system, it normally requires an underground length of conduit and cable connecting the building system with the underground valve switch outside the building. The housing of the device is made of a noncorroding material such as brass. The switch itself (Figure 2-20) is a magnetically operated sealed reed switch. When the valve is in its normal position, a magnet is adjacent to the reed switch. As the valve is operated, the magnet moves away from the reed switch. When the valve wrench or key has rotated two full turns, the magnet is far enough away from the reed switch to actuate it. Switch actuation causes a supervisory signal at the control unit and/or remote receiver.

3.7.1.5 Testing and Maintenance of Valve Position Supervisory Devices For efficiency, valve position supervisory devices are normally tested when other devices in the same location are being tested. They should be tested annually. Test the valve by turning its handle two turns or 20% of its range from its normal position. Check local indicating device operation and remote signals while the valve is in this position. If all signals are normal, restore the valve to its normal position, turn off local signals, and check for restoration of remote signals. Obtain telephone or radio communications with the remote receiving location before starting tests which include remote signaling.

3.7.1.6 Troubleshooting. The usual defect discovered during testing is a failure of local and remote signals to operate when the valve handle is turned two turns. When this occurs, operate the valve handle slowly beyond the two turns. If switch operating parts are visible, check them during valve operation. Look for loose mounting bolts, improper switch adjustment, or improper installation.

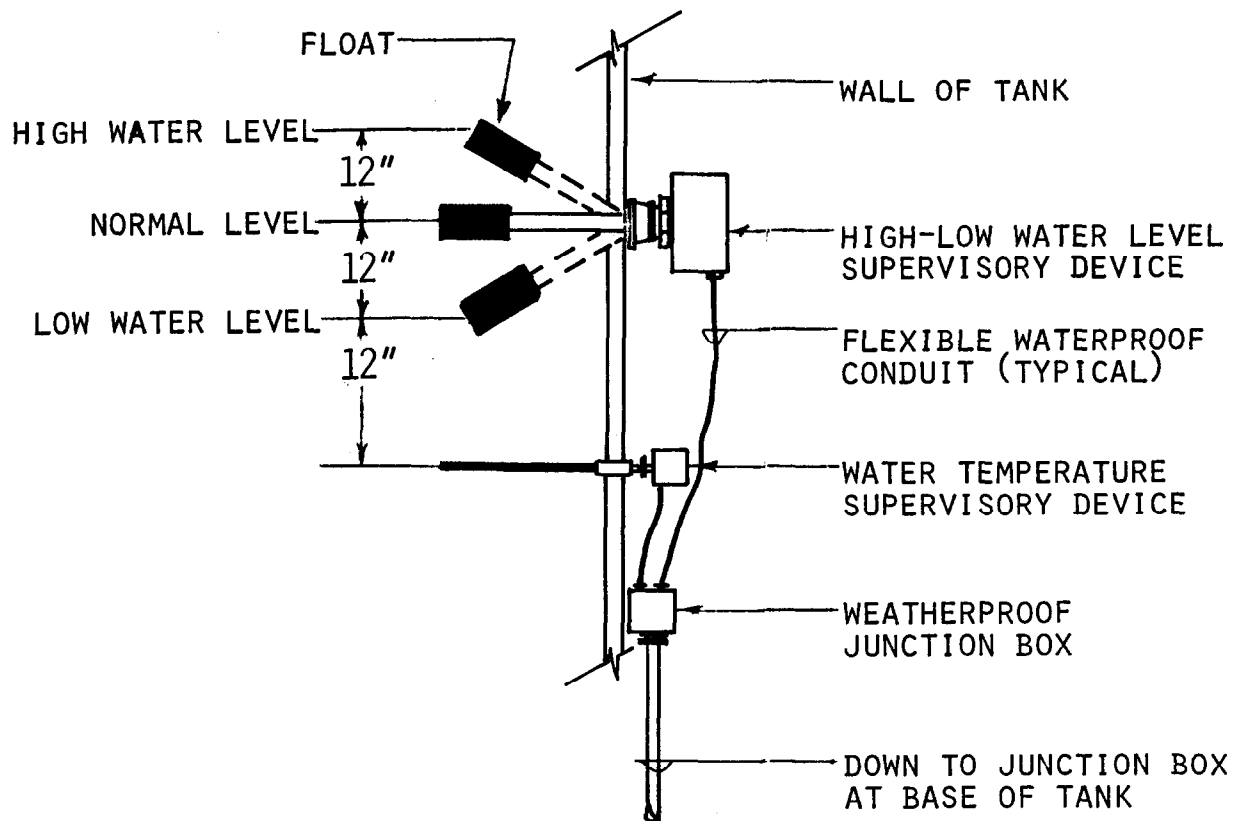
Valve position indicating switches actuated by a groove cut in a valve stem are frequently damaged by improperly cut grooves. If the groove is not gradual or tapered enough, the valve stem movement may bend the lever or plunger of the switch. In some cases the damaged part can be repaired, but generally the most reliable repair is replacement of the complete device and reworking the stem groove. Undamaged parts of the removed device can be used as spare parts.

If adjustment and the groove in the valve stem are normal, look for broken wires and improper connections at the valve position switch terminals. Always restore the valve to its normal position after testing or repair and check with the remote receiving location to confirm that signals indicate conditions are normal.

3.7.2 Water Level Supervisory Devices. The water level in sprinkler system reservoirs must be maintained within certain limits and there are usually automatic controls for maintaining the desired water level. Water level supervisory devices cause a supervisory signal when the water level is not maintained between the desired high and low limits.

3.7.2.1 Float-Actuated Level Indicator. A float-actuated level indicator is illustrated in Figures 2-21 and 3-28. The device is mounted outside on the rigid wall of a tank and a float and lever arm extend into the tank through a hole in the tank wall. A gasket seals the edges of the hole to the device. The float is held up by the water in the tank and the lever arm follows the up or down motion of the float as the water level changes. The

lever arm is pivoted at the wall of the tank. The end of the lever away from the float is arranged to operate one or two switches (one for high and one for low levels) when the float moves outside of normal limits. Some float-actuated devices use a chain connection to operate the switch rather than a lever.



SECTION THROUGH TANK

FIGURE 3-28
INSTALLATION OF WATER LEVEL AND WATER TEMPERATURE SUPERVISORY DEVICES

3.7.2.2 Pressure-Actuated Level Indicator. The pressure-actuated level indicator switch is physically very similar to the bellows-operated pressure switches used for waterflow detection shown in Figure 3-22. As the water level changes in a reservoir, the water pressure at the level supervisory switch also changes. The switch can be adjusted to actuate when pressure indicates a low water level or high water level. The switches may be two separate devices with different pressure settings or a single device which causes a signal for pressures outside of the normal range. The device is usually connected to piping near the bottom of the reservoir.

3.7.2.3 Electronic Level Indicators. Electronic level indicators usually read the conductivity of water to cause an electrical signal. One arrangement uses long parallel electrodes which become immersed in the water if it rises above a desired level. When the electrodes are in the water, current flow through the water, between the electrodes, is sensed by the associated electronic circuitry. This type of device is most frequently used to signal high water level and seldom used for fire protection water reservoirs.

3.7.2.4 Testing and Maintenance of Water Level Supervisory Devices. Water level supervision devices are sealed with gaskets and switch contacts are usually made of precious metal. They seldom need repair or replacement. Terminal connections and mechanical linkages should be inspected annually and cleaned or tightened as necessary. Testing of water level supervision devices should be performed semi-annually. When inspecting, simulate a supervisory signal from the device. Manual operation of float levers or switches confirms integrity of signaling circuits and critical working parts. Short circuiting device terminals with a screwdriver in a normally open circuit or opening a normally closed circuit confirms circuit integrity.

If the device to be inspected is located on an elevated tank, follow proper safety procedures during inspection. If a water level supervisory device fails, replace only the defective part if possible. Mounting an entire device may involve draining the reservoir. When opening a sealed housing, be careful not to lose screws or other small specialized parts and not to damage gaskets. On reassembly, tighten cover screws firmly but do not overtighten causing gasket damage or making future inspection difficult.

3.7.2.5 Troubleshooting. To troubleshoot water level supervisory devices, purposely cause an abnormal water level and note the performance of the water level detector. If a float lever does not move with changing water level, operate the lever manually. If the lever operates smoothly, the float may be leaky and full of water and it should be replaced. If the lever does not operate smoothly, clean the linkage and service it according to the manufacturer's recommendations. If float and linkage operation appears to be normal, and switch actuation simulation (by short circuiting switch terminals in a normally open circuit or by disconnecting a wire in a normally closed circuit) causes a supervisory signal, the switch is defective and should be replaced.

3.7.3 Electric Fire Pump Supervisory Devices. Electric fire pump supervisory devices detect two abnormal electric fire pump conditions: electric power off and pump running. The power must be on for the pump to be ready for use. If the pump is running, the abnormal condition signal indicates that the sprinkler system is operating and requires more water than can adequately be supplied by other sources. (See Chapters 4 and 5 for more information on fire pumps.)

3.7.3.1 Pump Power Failure Indicator. The pump power failure indicator is an AC relay that is energized when pump power is available. When power fails, the relay deenergizes, causing a supervisory signal. For this feature, the power to energize the relay comes from a point ahead of the pump controller switch that energizes the pump. When pump power fails, the normally energized relay deenergizes, causing a supervisory signal at the supervisory control panel which has its own power supply.

3.7.3.2 Pump Running Indicator. The pump running signal may be initiated by a set of contacts designed into the pump controller for that purpose or by an added relay. The relay is energized by the same power that runs the pump, so that when power is switched on by the controller to run the pump, the normally deenergized relay is energized causing a supervisory signal.

3.7.4 Engine-Driven Fire Pump Supervisory Devices. Engine-driven pumps are supervised for pump power failure and pump running as well as several other abnormal conditions not supervised for electric pumps.

3.7.4.1 Pump Power Failure Indicator. Even though the pump is engine driven, it requires electrical power to start the engine. This power is normally supplied by a rechargeable battery charged by an AC-powered battery charger. The readiness of the battery to start the engine depends on a constant supply of AC power. The power is supervised in the same way as for an electric fire pump.

3.7.4.2 Pump Running Indicator. The pump running indication for an engine-driven pump is usually provided by contacts in the pump controller. Sensing of pump running is accomplished by a centrifugal switch at the engine. Actuation of that switch causes relay action at the controller. Contacts of that relay are used for supervisory signaling.

3.7.4.3 Engine Malfunction Indicator. A fire pump engine controller normally has separate supervisory signal initiating contacts for several conditions which are symptoms of engine malfunction. These conditions may be individually supervised or their associated contacts may be connected to provide a single engine malfunction supervisory signal. Conditions indicated include: failure of the engine to start, low oil pressure, high water temperature, overspeed, and others. All these supervisory signals are initiated by individual relay actuation in the engine controller. Actuation of each controller relay is caused by a sensor and associated electronic circuitry at the engine. The sensors, electronic circuitry and relays in the controller are parts of modern, engine equipment whether or not there is a supervisory signaling system.

In newer equipment, a failure to start condition is sensed by electronic counting of cranking cycles. In older equipment it is sensed by the rise in temperature of a starter current sensor. Low oil pressure is sensed by a bellows type pressure switch. High water temperature of cooling water is sensed with a thermostat. Overspeed (indicating engine governor failure) is sensed with a centrifugal switch which may be the same switch used for a pump running indication. The sensing of a malfunction condition causes a supervisory signal and shutdown of the engine to avoid engine damage.

3.7.4.4 Hand-Off-Automatic (HOA) Switch Position Indicator. The pump engine controller provides several modes of control selected by a multi-position switch on the controller panel. In the "off" position of the switch the engine will not run. In the "hand," "manual," "on," or "test" (the label varies with different manufacturers) position of the switch, the engine starter is activated and the engine starts, if other conditions are normal. When the HOA switch is in the automatic or normal position, the pump starts automatically on pressure demand and may be arranged to shut off automatically at the end of a timed period (usually about 6 minutes) if water demand

conditions no longer require the pump to run. However, some pumps are arranged for automatic starting, but only manual shut off. If the HOA switch is in any position other than automatic (normal), it causes relay actuation in the controller which causes a supervisory signal.

3.7.4.5 Fuel Level Indicator. A float-actuated switch in the fuel tank causes a supervisory signal when almost empty.

3.7.4.6 Testing and Maintenance of Fire Pump Supervisory Devices. Fire pump supervisory devices that can be tested without risk of engine damage should be tested annually. To test, cause an abnormal condition, if practical, and note the signals received at the building supervisory control panel and at the remote signal receiving location.

- Pump Power Failure Indicator. For both electric and engine-driven fire pumps, test by operating the disconnect switch supplying power to the pump or engine. This should not be confused with any separate disconnect switch supplying power to a smaller jockey pump. Turn the disconnect switch to the "off" position, note the proper receipt of signals, restore the switch to the "on" position, and note the restoration of signals to their normal condition.
- Pump Running Indicator. Actuate the pump running supervisory device by running the electric or motor-driven fire pump. The pump may be manually switched on or the water pressure at the pump controller can be reduced to the "pump on" pressure by releasing water at the test cock, usually provided at the controller. Reclose the test cock after the pump starts. Confirm the proper receipt of signals, wait for the pump run timing period to expire, usually 5 to 7 minutes, and confirm restoration of signals to their normal condition when the pump stops. To stop the pump, if a pump timer is not installed, turn the HOA switch to the "off" position and then to the automatic" position.

If both HOA switch supervision and pump running supervision are provided on the same initiating circuit, conduct the pump running test by bleeding off water pressure at the controller test cock, not by operating the HOA switch. If pump running supervision is tested by switching the HOA switch to the "hand," "on," or "test" position, it may not be possible to determine if the signal was initiated by the pump running or by the HOA switch position supervisory device. Otherwise, the HOA switch supervisory signal and the pump running signal on the same circuit cannot be distinguished.

- Engine Malfunction Indicator. The engine malfunction conditions of low oil pressure, high water temperature, and overspeed must be simulated. Actually causing the condition would risk engine damage. To simulate malfunction conditions, short circuit or jump the individual sensing switches, one at a time. See the engine controller manufacturer's installation and operation manual for the proper terminals to jump for simulation. There is usually a delay provided for actuation of the low oil pressure signaling relay so that momentary drops in pressure do not cause a supervisory signal. When simulating low oil pressure, maintain the jumper connection for 20 seconds or more.

The failure to start condition is usually simulated by disconnecting the wire that controls the fuel solenoid and operating the HOA switch to the "hand," "manual," or "test" position. This causes the starter to crank the engine, but the engine will not start due to a lack of fuel. After approximately six cranking cycles the "failure to start" signal should be initiated. If HOA switch position is supervised on the same circuit with engine failure to start, cause engine cranking by bleeding off water pressure at the controller test cock.

- Hand-Off-Automatic (HOA) Switch Position Indicator. Operation of the HOA switch to the "off" position should cause a supervisory signal indicating that the switch is in a position other than "automatic" or "normal." Operation of the switch to the "hand," "manual," or "test" position should also cause this same supervisory signal, but HOA switch supervision may be connected to the same circuit (zone) as the pump running signal. Operating the HOA switch to the "hand," "manual," or "test" position causes the engine to run and causes a pump running signal. The HOA switch supervisory signal and the pump running signal on the same circuit would not be distinguishable.
- Fuel Level Indicator. Simulate a low fuel condition by jumping the float switch terminals. Consult the engine controller manufacturer's manuals to see which terminals to jump.

3.7.4.7 Troubleshooting. Consult the engine controller manufacturer's manuals for recommendations in troubleshooting the built-in sensors and relays. Service added-on relays for supervising pump power failure and electric pump running according to the earlier section on relays in this chapter. Usually, troubleshooting will involve locating the relay associated with the particular signal that failed, removing that relay and adjusting, repairing or replacing it.

3.7.5 Temperature Supervisory Devices. Temperature supervisory devices are used to avoid freezing water for fire protection systems.

3.7.5.1 Low Air Temperature Indicator. Wet pipe sprinkler systems are used only in heated buildings because sprinkler pipes otherwise would freeze in cold weather. A low air temperature device may be located in each cold area of a building where the earliest freezing of pipes is expected if heating fails. The usual temperature settings used are 40° and 45°F. In a shipping dock area, which often may have doors open, usually the lower (40°F) setting is used. The 45°F setting is for spaces which are normally kept at a higher temperature. The devices may be adjustable thermostats or they may be sealed factory-set thermostats. Figure 2-15 is a photograph of an adjustable device frequently used.

3.7.5.2 Low Water Temperature Indicator. Low water temperature devices are usually installed in outdoor water reservoirs. They are usually sealed factory-set thermostats. They may also have a high temperature setting in the same device. The most frequent low temperature setting is 40°F. The high temperature setting, if provided, is usually 140°F. Figure 3-28 shows a temperature sensing device as installed through the wall of a reservoir.

3.7.5.3 Testing and Maintenance of Temperature Supervisory Devices. Temperature supervisory devices should be tested semi-annually. Both the sealed and adjustable low air temperature devices may be tested by spraying with an aerosol coolant spray often used for testing of electronic parts and circuits. The adjustable devices may be tested by an alternate method if the adjustment range of the thermostat includes the room temperature existing at the time of the test. The original setting is first noted, and the adjustment is changed toward the existing room temperature. A low temperature supervisory signal should result when the adjustment passes the existing room temperature. Confirm the proper receipt of signals and restore the thermostat adjustment to its original setting.

It is usually impractical to perform a complete test of a low water temperature supervisory device because the device is submerged and the sensing element is inaccessible. If the sensing element can be removed from the housing, it can be tested with coolant spray as described for the low air temperature device. Otherwise, test the circuit up to the device terminals by short circuiting the terminals for a normally open device or removing a wire from a terminal for a normally closed device. This simulates a temperature supervisory signal. At test time, the terminals should be inspected and cleaned of any corrosion. Check tightness of terminal screws.

3.7.5.4 Troubleshooting. Temperature devices which do not respond to the test should be replaced and the defective device returned to the manufacturer for repair.

3.7.6 Air Pressure Supervisory Devices. Air pressure supervisory devices are bellows actuated pressure switches as described in Section 3.6.5.1. Usually the air pressure supervisory devices are adjusted to actuate at lower pressures than the water pressure sensors.

3.7.6.1 Dry Pipe Sprinkler Air Pressure Indicator. Both high and low air pressures are usually supervised for a dry pipe sprinkler system. One device with a high and a low setting is used. The low setting is 5 to 10 psi above the lowest safe system air pressure to avoid unintentional tripping of the dry pipe valve. That lowest safe air pressure is determined by the dry pipe valve design and the water supply pressure, including surges. The high air pressure setting for the supervisory device is usually 18 to 20 psi above the low pressure setting.

The meaning of a low air pressure supervisory signal is that the normal means of maintaining air pressure has failed and must be corrected soon or the dry pipe valve will trip. A high air pressure signal means that the pressure switch controlling the compressor has failed to turn off and damage to the compressor may result if power is not immediately disconnected. Manual control of the compressor would be required until the switch is repaired.

3.7.6.2 Heat-Actuated Device (HAD) Air Pressure Indicator. Heat-actuated devices are pneumatic devices frequently arranged in a system which is slightly pressurized. An almost constant low pressure of a few ounces per square inch is maintained by a small compressor so that an air leak in the system can be detected. The low air pressure switch is usually factory-set at a pressure slightly below the normal starting pressure for the compressor.

3.7.6.3 Pressure Tank Air Pressure Indicator. A pressure tank air pressure supervisory device causes a signal for air pressures outside the normal range in a pressure tank type water reservoir. Similar to the high/low air pressure switch for a dry pipe system, it is usually mounted on the reservoir tank wall.

3.7.6.4 Testing and Maintenance of Air Pressure Supervisory Devices. Test air pressure supervisory devices semi-annually when other devices in the area are being inspected or tested. Test pressure sensors for dry pipe and HAD systems carefully. Dropping the air pressure to obtain a low pressure signal can cause unintentional tripping of a dry pipe valve or other associated sprinkler system.

- Dry Pipe Sprinkler Air Pressure Supervisory Device. Before testing, calculate the approximate air pressure for tripping the dry valve so an unsuccessful test can be stopped before that pressure is reached. Note the water pressure on the supply side of the dry valve and add approximately 20 psi to that reading to allow for possible pressure surges during the test. Divide that pressure by five (or actual ratio between supply water pressure and system air pressure for the particular valve) to obtain the lowest safe air pressure. A more precise figure should be on the manufacturer's instruction sheets for the dry valve. Note whether an accelerator or exhaustor is provided for the dry pipe system.

Slowly bleed air from the system side of the dry valve fast enough to register on the gauge, but not so fast as to risk tripping the dry valve. Use the small globe valve or lever valve provided for the purpose. Keep the rate of pressure drop quite slow if an accelerator or exhaustor is installed. At some pressure, the air maintenance compressor should start. Note that pressure, shut off the compressor power, and continue bleeding off air. A low air pressure supervisory signal should be initiated 2 to 5 psi below the compressor starting pressure and at least a few psi above the lowest safe air pressure calculated above.

During the test, check the supply water pressure gauge occasionally for any increase in pressure which could affect the lowest safe air pressure previously calculated. If water pressure changes, recalculate the low air figure so that the test can be discontinued before that pressure is reached. When the low air pressure supervisory signal is obtained, note the air pressure reading for future reference, close the bleed-off valve and restore compressor power. Be sure the supervisory signal restores to a normal indication when the air pressure is back within its normal range. Note the pressure at which the compressor shuts off.

A high pressure supervisory signal is often difficult to obtain in a dry pipe system since it requires bypassing the pressure switch contacts which cause the compressor to shut off when normal pressure is reached. Usually the easiest way to do this is to jumper the switch terminals. To avoid electrical shock, turn off compressor power first, jumper the terminals and then restore power. The high air pressure supervisory signal should be obtained when air pressure reaches 5 to 15 psi above the normal compressor cut-off pressure. If the pressure relief valve opens, relieving the excess pressure, before the

supervisory signal occurs, check 'if the compressor control settings and the low pressure supervisory signal setting were correct. Discontinue the high pressure test if other settings were proper. Shut off compressor power, remove the jumper, and restore compressor power. Bleed off system air pressure until restoration of the high pressure signal to normal (if it was obtained) occurs. Close the bleed-off valve.

- Heat-Actuated Device (HAD) For Air Pressure Supervision. HAD systems are often used as the fire detectors for deluge sprinkler systems or other special hazard fire extinguishing systems. Test HAD air pressure supervisory devices very carefully or the associated fire extinguishing system may be actuated, causing water damage and disruption of normal activities. Mechanically deactivate any associated fire protection system using the manufacturer's recommended method before starting the test.

Locate the test plug in the HAD header block (it is usually a hexagonal headed plug). Loosen the plug only slightly to allow a slow leak of air from the HAD system. Observe the pressure drop on the gauge usually supplied for this purpose, and note the pressure at which the low pressure supervisory signal occurs. When the air pressure maintenance compressor starts, note the pressure and whether or not the pressure continues to drop. It may be necessary to turn off compressor power or increase the rate of air loss to cause the pressure to continue to drop and reach the low pressure supervisory signal setting. After obtaining the signal, tighten the test plug and restore compressor power. Test for air leaks at the test plug with soapy water or other bubble solution, and retighten the plug if necessary. Confirm that the low pressure signal restores to a normal indication, and reactivate any associated fire protection system.

- Pressure Tank Air Pressure Supervisory Device. Test this device the same way the air pressure supervisory device for a dry pipe sprinkler system is tested. Test for low pressure actuation of the device by releasing air from the tank to obtain the low pressure setting. It may be necessary to shut off power to the air maintenance compressor to permit an uninterrupted pressure drop. Test for high pressure actuation of the supervisory device by jumpering the compressor control switch terminals which normally open when normal pressure is reached. Install and remove the jumper with compressor power off to avoid electrical shock. Restore compressor power with the jumper on to increase pressure and obtain the high pressure signal. Remove the jumper when the high pressure signal is obtained. Release air again to restore normal pressure to the tank. Confirm that' supervisory signals restore to their normal indication.

3.7.6.5 Troubleshooting. The most frequent cause of failure in pressure supervisory devices is misadjustment of the pressure switches at installation. If pressure switches have operated properly in the past and records are kept at the pressure settings obtained during previous tests, a failure to obtain approximately those same readings indicates either a circuit problem or device failure. (See Section 3.5.3 for circuit troubleshooting.)

A device failure usually requires replacing the device, adjusting the new device to the old settings, and returning the defective device to the manufacturer for repair. Have the manufacturer adjust the pressure set points to the requirements of the application.

3.7.7 Other Supervisory Devices. Other supervisory devices may be encountered. They will usually be designed for unusual situations which do not allow the use of the more common supervisory devices. The principles of operation are generally the same as those discussed, but physical mounting provisions or other details may vary. Figure 2-23 shows a supervisory device for sprinkler control valves which is used only when the standard OS&Y or butterfly valve supervisory devices cannot be used. If the valve handle is rotated to close the valve, tension on the waterproof cable looped through the valve handle pulls out a plug from the device and breaks the normally closed supervisory circuit. A similar device, used in normally open circuits, uses a magnet and reed switch.

3.7.7.1 Testing and Maintenance of Other Supervisory Devices. Test other supervisory devices annually by creating or simulating the abnormal condition, confirming the receipt of supervisory signals, restoring the condition to normal, and confirming restoration of supervisory signals to their normal indication.

3.7.7.2 Troubleshooting. Determine first whether the failure is a circuit or a device failure. Electrically simulate the device actuation by short circuiting device terminals for normally open circuits or by disconnecting a wire for normally closed circuit. If signals are properly initiated by simulation, the device in question is defective. If the problem still exists, the circuit is defective and further tests are required to locate the fault (see Section 3.5.3).

3.8 ALARM INDICATING DEVICES. Alarm indicating devices are the lights or sounding devices that indicate a fire alarm or abnormal condition. These lights and sounds may also provide information about where the signal originates.

3.8.1 Visual Alarm Indicators. There are various types of lights for visual alarm indicators.

3.8.1.1 Zone Annunciator Lamps. Zone annunciator lamps are described in Section 3.3.9. Figure 2-2 is a photograph of an annunciator which uses incandescent lamps.

3.8.1.2 Flashing Evacuation Alarm Lamps. Evacuation alarm lamps are usually installed with an audible device. The flashing feature is sometimes created by pulsating the power source for only the lamp at the control unit or by a thermostatic or solid state flasher built into the evacuation alarm lamp assembly. The lamp assembly with built-in flasher does not provide supervision of the operability of the flasher and a defective flasher is not detected until a test or alarm occurs.

3.8.1.3 Rotating Evacuation Alarm Beacons. Rotating beacons provide a flashing light. The power source is constant during an alarm and, instead of a flasher, the beacon assembly contains a motor and gear drive which rotates a set of reflectors around a centrally located lamp.

3.8.2 Audible Alarm Indicators. Audible alarm indicators are electromagnetic devices which produce sound when energized.

3.8.2.1 Bells. A bell consists of many of the same parts as a relay and operates on the same principle. The bell contains an electromagnet composed of a coil and core. The core is magnetized when the coil is energized with electric current. A pivoted, spring-loaded armature is attracted to the core when the core is magnetized. As the armature moves toward the core, a set of contacts connected in series with the power source is interrupted by the armature movement and power is disconnected from the coil. The spring returns the armature to its original position, closing the contacts and restoring power to the coil to start a new cycle.

A bell clapper is attached to the armature and physically arranged so that it strikes a gong with each cycle of vibration. The clapper may be a pivoted lever type or a plunger type. In the plunger type, the plunger becomes the moving core of a solenoid when the coil is energized, otherwise the operation is similar to the pivoted lever type. A typical bell is shown in Figure 2-8.

In single stroke bells, the contacts are eliminated. The electromagnet prevents full rebound of the clapper after the gong is struck until power is removed. Each new application of power causes a single full stroke of the clapper. Single stroke bells are frequently used in coded building alarm systems.

3.8.2.2 Horns. Some horns operate like bells. There is an electromagnet with its coil and core, and the armature which is attracted to the core is the vibrating diaphragm that causes the noise. A set of contacts connected in series with the power source is operated by the vibrating diaphragm just as the contacts were operated by the armature in the bell. Figure 2-8 shows a typical horn of this type. Other horn designs use a motor driven cam to vibrate the diaphragm,

3.8.2.3 Chimes. Chimes operate very much like the single stroke bell. In chimes, the moving part is a plunger which also acts as the core of a solenoid. When power is applied, the plunger moves to strike a flat rectangular plate and rebounds enough to allow the plate to continue to vibrate. When power is removed and reapplied, the plunger strikes the plate again, one time for each power application. The chime is not as loud as the other audible devices so it is popular for hospital use and for some coded building alarm systems. Figure 2-8 shows a typical chime.

3.8.2.4 Speakers. Speakers are becoming increasingly popular for alarm use because of their versatility. They can reproduce a variety of sounds. In multi-story building alarm systems, speakers may be used to reproduce a siren type sound alternating with a recorded message which gives evacuation instructions (that is, provides text material, thereby referred to as textual indicating device).

Speakers are electromagnetic devices also. There are many speaker designs but one of the most common is the permanent magnet speaker. The speaker coil is cemented to the center of the speaker cone. The coil is located within the magnetic field of a permanent magnet. Sound is reproduced by supplying a varying alternating current to the speaker coil from an amplifier. The alternating current causes the coil to produce its own varying magnetic field which alternately opposes and reinforces the fixed magnetic field of the permanent magnet. The coil experiences a varying magnetic force which causes the core to vibrate at the frequency of the alternating current and with an amplitude proportional to the amplitude of the alternating current.

3.8.2.5 Testing and Maintenance of Alarm Indicating Devices. Test alarm indicating devices monthly with the monthly inspection. When convenient, the test may be combined with a fire drill. Test by operating the drill switch or the test switch at the control unit or by actuating an initiating device. If the test switch or an initiating device is used, notify the remote alarm headquarters because remote signal transmitters and other auxiliary features will be actuated by such a test.

While there is an alarm condition, check all the indicating devices and note any that fail to operate properly. Audible devices should produce loud, clear, consistent tones and coded system codes should be clearly readable. Visual devices should be bright and steady or pulsating, as intended.

Inspection of indicating devices should be planned such that every device is tested at least once a year. A record should be maintained documenting tests of indicating devices for the previous five years. Test annunciator lamps by operating a "lamp test" switch, if it is provided. Otherwise, cause an alarm and a trouble condition on each zone. It is usually convenient to cause these conditions at the control unit initiating circuit terminals. Remote annunciators should be tested semi-annually for proper operation.

3.8.2.6 Troubleshooting. Periodic cleaning may be required for indicating devices. A recommended checking and cleaning procedure may be included in the manufacturer's literature. The frequency of cleaning needed depends on the ambient conditions. When a single indicating device fails to operate, it is usually defective. If a group of devices fails to operate, the fault is usually a defective circuit. Circuit troubleshooting was discussed earlier in this chapter in the section about maintenance of control and auxiliary units (Section 3.5.3).

- Zone Annunciator Lamps. When annunciator lamps fail to function, it is either because the lamp is defective or the lamp is not making proper contact with the lamp socket. See Section 3.3.9 for methods of checking lamps and sockets.
- Flashing Evacuation Alarm Lamps. Check lamps from a flashing lamp assembly that fail to function using information in Section 3.3.9. If the lamp is good but still fails to function in the assembly, check that voltage from the control unit is present at the assembly terminals. If voltage is present, replace the flasher and return the defective flasher to the manufacturer for repair or replacement.

For lamps connected to control equipment that supplies a pulsating voltage for signaling an alarm, failure of good lamps to flash or light at all indicates a failure of the pulsating power source in the control unit. Proceed with troubleshooting or return of equipment to the manufacturer.

- Rotating Evacuation Alarm Beacons. If a rotating beacon fails to light but voltage is supplied, it indicates lamp replacement is necessary (see Section 3.3.9). If the lamp lights, but the reflector assembly fails to rotate, a motor or gearing failure is the probable cause. Unless a solution is obvious, return the complete assembly to the manufacturer for repair.
- Bells. Defective bells usually require contact cleaning or gong adjustment. (Some bell designs do not provide for gong adjustment.) Clean contacts with a burnishing tool, a common

repair tool for relays. If the bell buzzes but does not ring, adjust the gong. Bells that allow for gong adjustment have a gong with an off-center mounting hole so that rotation of the gong around the mounting bolt moves the inner surface of the gong rim closer to or away from the bell clapper or plunger. Only slight adjustment should be necessary.

If no sound is obtained after contact cleaning, check continuity of the bell coil. Infinite resistance indicates a burned out coil or a broken wire. Replace the coil if practical or return the bell to the manufacturer for repair.

- Horns. Horns which fail to operate or produce adequate sound usually require adjustment. A small screw adjustment is usually provided for volume adjustment. Make the adjustment while power is applied so that the desired volume can be determined during the adjustment. Check the manufacturer's material to locate the adjustment screw. If horn volume is still inadequate or intermittent, clean contacts with a burnishing tool, such as used for relay contacts. Some disassembly of the horn is necessary to reach the contacts.
- Chimes. Chimes are single stroke devices that only produce the conventional chime sound when subjected to a pulsating voltage. Unsatisfactory chime performance may be the result of application of a nonpulsating voltage rather than a defective chime. If a chime does not perform properly with a pulsating power source, check coil continuity with an ohmmeter and replace the coil if there is no continuity. If the coil shows continuity and there is some plunger motion when power is applied, the problem may be because of dust or dirt or wear between moving parts. Disassembly of the parts, cleaning, and reassembly may cure the problem. The parts may be lightly lubricated, if recommended by the manufacturer.
- Speakers. If a speaker rattles during an alarm, mounting screws may be loose. Intermittent performance may indicate loose connections at terminal screws. Tighten mounting and terminal screws firmly. Fuzzy sound may be due to a damaged cone. Return speakers with damaged cones to the manufacturer for repair. Failure of a speaker to operate may indicate that its coil is defective. Check coil continuity and, if found to be infinite, return the speaker to the manufacturer for repair.

3.9 CONNECTION OF BUILDING ALARM TO BASE ALARM SYSTEM. To have continuous monitoring of building alarm systems without having individual personnel continuously on duty at the buildings, many military bases have a base alarm system with individual alarms throughout the base connected to transmit signals to a central location.

3.9.1 Signals Transmitted to Base Alarm Headquarters. The types of signals transmitted to the base fire alarm headquarters are usually limited to the following:

- Fire Alarms (waterflow, automatic fire detection, manual, and evacuation signals).
- Sprinkler Supervisory (closed valves, low temperature, and fire pump signals) .
- Building Fire Alarm System Trouble (circuit problems and power off).

Other types of alarm signals are not usually transmitted to the fire alarm headquarters to avoid possible confusion of signals which could reduce the effectiveness of fire protection. Burglar alarm signals, industrial process signals, and environmental control system signals are usually transmitted to a separate location. Some sophisticated multiplex systems transmit all the above types of signals to one location with fire alarm related signals taking first priority and causing different, easily distinguishable audible and visual indications at the receiving console.

3.9.2 Connection to Noncoded Base Alarm System. Noncoded base alarm systems are usually the reversal signal or the direct wire type. Both types require a pair of telephone type wires or one wire and an earth ground connection. Reversal signal transmission is discussed in Chapter 2, under "Base Alarm System Components," and earlier in this chapter (Section 3.4.1).

Direct wire signal transmission requires a way to change the signaling circuit resistance at the transmitter end so that current changes at the receiver can be interpreted as trouble, normal, and alarm conditions. The power source for direct wire signaling circuits is usually located at the base fire alarm headquarters. The wires may run overhead or underground between transmitter and receiver, and there is a separate transmitter/receiver pair for each connection to the base system. The receiver is usually a plug-in module in a receiver rack or cabinet.

3.9.3 Connection to Coded Base Alarm System. Coded base alarm systems may be McCulloh, municipal, or multiplex types. Signal transmission and wiring for McCulloh and municipal types between coded transmitters and the receiver are similar. A pair of wires and an earth ground connection connect the transmitter with the base signaling circuit. The pair of wires connects the transmitter into the series loop circuit which terminates at the receiver. The ground connection provides the Class A capability to transmit and receive signals with one fault on the circuit. Consult NFPA 72B for further detail on the various municipal transmitter tripping methods and wiring from building systems to municipal transmitters.

Various multiplex system designs place different requirements on the interconnecting wiring. Most designs require shielded cable between remote locations and the receiver. Figure 2-25 is a block diagram of a typical multiplex system.

3.9.4 Bypassing Base Alarm Connection for Building Alarm System Testing. To facilitate testing alarm systems in buildings without causing unnecessary alarm signals at the base fire alarm headquarters, building alarm systems frequently have a switch for deactivating the building connection to the base system. Operating the switch to the bypass position usually causes a trouble

indication at the building control unit as a reminder to reactivate the connection to the base system when tests are completed. Because of the possibility of leaving a building system disconnected from the base system, some local authorities do not allow the use of bypass switches.

3.10 BASE ALARM SYSTEM EQUIPMENT. The method of connecting alarm systems or devices to the base alarm system depends on the number or density of signal initiating devices in a building or area as well as the type of base system. If many initiating devices are located in a building, they are usually part of a building system. If initiating devices are further apart, such as one device per building, there may be no building system.

3.10.1 Connection to Building Alarm System. Building alarm systems have a control unit where all wiring for the system terminates. Building systems are connected to the base alarm system by an auxiliary alarm relay or relays in the control unit. This relay may act as the remote signal transmitter (as in current reversal base systems), may cause actuation of a transmitter (as in McCulloh or municipal transmitter base systems), or may cause a change in state which is interpreted as an alarm by a base multiplex system.

When there is a building system, one fire alarm transmitter for the building is actuated by the building control unit. There may also be a separate transmitter for the building supervisory devices actuated by a supervisory auxiliary relay in the supervisory control unit. The supervisory control unit functions may be performed by the fire alarm control unit.

3.10.2 Direct Connection to Fire Alarm Supervisory Device. Individual coded initiating devices are frequently connected directly to the base alarm system, not to a building system, particularly in the case of McCulloh coded base alarm systems. The coded initiating device may also have switch contacts which are connected to cause an alarm in a building system or simply to cause sounding of one audible device near the initiating device. Direct connection of initiating device transmitters to the base alarm system is usually used when there are only one or two initiating devices in a building. A typical application of this type may have two sprinkler waterflow transmitters and a sprinkler supervisory transmitter in a warehouse connected to a base alarm system McCulloh signaling circuit. The two waterflow transmitters may each ring a local bell to alert occupants and to localize the cause of any alarm.

3.10.3 Base Alarm System Circuits.

3.10.3.1 Telephone Type Wiring. Telephone type wiring circuits are characterized by central offices where all the telephone line pairs for areas near the central office are routed and any permanent connections between the individual pairs are made. Modern telephone type wiring is also underground and is maintained by a civilian telephone company or a military branch specializing in communications.

- Noncoded Remote Station. A noncoded remote station has individual receiver modules for each fire alarm or supervisory transmitter. A pair of telephone wires, or one wire and a ground connection, connect each transmitter with each receiver module. That pair of telephone wires is dedicated for the transmission of signals from only that one transmitter to its remote station receiver module.

- Coded Central Station. A coded central station typically uses the McCulloh coded signaling method. A McCulloh signaling circuit is a loop, both ends of which terminate at the receiver. A number of transmitters, typically 10 to 25, is connected to each signaling circuit.

Each transmitter has its normally closed coding contacts connected in series with the loop. Each transmitter and the central station have an earth ground connection independent of the telephone type wiring. The circuit is electrically a loop, but is physically formed from conventional telephone line pairs.

- Multiplex. In a multiplex type base alarm system, each building protected by the system typically has one or more data gathering pane-is with signal initiating circuits connected. Each data gathering panel is typically connected to the multiplex receiver with a voice grade shielded pair of telephone wires. See the block diagram of Figure 2-25.

3.10.3.2 Plant Type Wiring. Plant type wiring is independent from telephone facilities, including central offices, and is usually maintained by the user organization. Plant type wiring is totally dedicated to the use of the base alarm system and has its own conduit and junction boxes.

- Coded Municipal. A coded municipal base system is electrically very similar to the coded McCulloh system. However, the transmitter for the municipal system is usually located outside the building and is connected to the building system by a pair of wires which either supply energy from the building system for starting the transmitter (local energy trip) or form a shunt across the transmitter tripping coil and start the transmitter when the shunt circuit is broken (shunt trip) with energy from the alarm headquarters through the municipal circuit.
- Coded Proprietary. A coded proprietary base system is usually wired like the coded central station base system with the differences described under "Plant Type Wiring".
- Coded Multiplex. A coded multiplex base system is wired like the multiplex system described under "Telephone Type Wiring" with the differences described under "Plant Type Wiring".

3.10.3.3 Radio Frequency Type. The radio frequency type base system is similar to the municipal type system. The individual radio call box transmitter is not a part of the building system, but is a part of the base system and is located outside the protected building. There is wiring between the radio call box and the building system to trip the radio call box transmitter and maintain the rechargeable battery in the radio call box, if provided. There may be an interface panel in the building to provide the special features required by the radio call box and the functions usually provided by a building alarm system control unit. In addition it provides charging current for the radio call box battery, individual zone actuation of the radio call box, and supervision of interconnecting wiring between the interface panel and the radio call box.

The wiring between the building system and the radio frequency transmitter consists of at least a pair of wires for the fire alarm function and usually one additional wire for each additional coded function, such as individual fire alarm zones or supervisory signals. The link between the transmitter located near the building and the base fire alarm headquarters is radio frequency transmission instead of the wire used in the municipal type system.

3.10.3.4 Testing and Maintenance of Base Alarm System Circuits. Test the base alarm system circuits monthly under normal circuit conditions. Test Class A base alarm system circuits, those with the capability of continued operation with one fault on the circuit, quarterly under fault conditions.

The McCulloh circuit test with faults should be performed as follows:

1. Ground the signaling circuit at a transmitter, using the device ground. Confirm ground detection at alarm headquarters.
2. Have receiver monitoring personnel operate the circuit conditioning switch for circuit operation with a ground, if conditioning is not automatic.
3. Actuate a transmitter on each side of the ground fault separately and confirm that received codes are clear and identifiable.
4. Remove the ground fault from the circuit and confirm that a normal circuit condition is indicated at the receiver.
5. Have receiver monitoring personnel operate the circuit conditioning switch for normal operation if conditioning is not automatic.
6. Disconnect one wire of the signaling circuit at a transmitter. Confirm open fault detection at the receiver.
7. Have receiver monitoring personnel operate the circuit conditioning switch for operation with an open fault if conditioning is not automatic.
8. Actuate a transmitter on each side of the open fault separately and confirm that received codes are clear and identifiable.
9. Reconnect the disconnected wire, confirm indication at the receiver of circuit return to normal, and have receiver monitoring personnel operate the circuit conditioning switch for normal operation.

Tests for municipal type signaling circuits and other wired circuits should follow the same principles described for McCulloh circuits. Radio frequency required tests are conducted automatically each day in approved systems. Perform other tests according to equipment manufacturer's instructions.

3.10.3.5 Troubleshooting. Base alarm system receivers usually give automatic indication of a fault and the type of fault. Locate the fault the same as for Class A initiating circuits. Sometimes it is unnecessary to follow the detailed troubleshooting method if you remember that a transmitter which does not complete a cycle can cause a ground or open fault by stopping with signaling contacts in the grounded or open condition.

Review recently received signals on the circuit that has the fault to identify the last transmitter to operate before the fault appeared. Also check to see if all code sequences of that signal were complete. Check that transmitter to see if the coding cam is in its normal position. If not, rewind the spring motor or check the power supply for the transmitter. When power for the transmitter is restored, the code sequence should run to completion and remove the circuit fault.

3.10.4 Transmitters.

3.10.4.1 Noncoded Transmitters. Noncoded transmitters almost always consist of one or two relays arranged to reverse voltage and current on a pair of wires to the base alarm headquarters or to change resistance in the remote signaling circuit. The reversal relay arrangement is discussed in Section 3.4.1.6, "Remote Signal Transmitters." Relays are discussed in Section 3.3.1. The transmitting arrangement which causes a change in resistance has relay contacts which short circuit an end-of-line resistor or a portion of it so that a change in current can be detected at base alarm headquarters and interpreted on the basis of current value. The desired current values for different conditions are specified by the receiving equipment manufacturer.

3.10.4.2 Coded Central Station Type Transmitters. Coded central station transmitters are described in Section 3.4.1.6, "Remote Signal Transmitters ."

3.10.4.3 Coded Municipal Type Transmitters. A coded municipal transmitter is functionally similar to the coded central station transmitter except for the methods of actuation. Municipal transmitters are actuated by power supplied from a building alarm system control unit (local energy trip type transmitter) or by removing a shunt across the transmitter tripping coil, usually, by relay action at the building alarm system control unit (shunt trip type transmitter). The electrical energy for tripping the shunt trip type transmitter is supplied through the municipal signaling circuit from the fire alarm headquarters. Municipal transmitters with a manual alarm feature (master boxes) can be actuated manually as well as electrically (described above) . Municipal pull boxes, which are actuated only manually, may also be connected to municipal type circuits.

3.10.4.4 Coded Multiplex Type Transmitter. The coded multiplex transmitter is the data gathering panel. A description of its operation is in Section 2.3.2, "Base Alarm System Components," in the section on signal transmitters.

3.10.4.5 Coded Radio Frequency Type Transmitters. Coded radio frequency type transmitters (radio call boxes) function in base alarm systems the same way as municipal type transmitters in a municipal type base alarm system. A fire alarm in a building system connected to a radio call box causes the radio call box to transmit a coded alarm signal to the base fire alarm headquarters. The coded signal contains information on the type of "alarm (fire, trouble, or supervisory) , the zone affected, and low battery information, if the battery charge is low.

The radio call box is usually also capable of manual actuation to transmit police and ambulance call signals. Radio call boxes which are actuated only manually may also be a part of a base system. Tampering, tilting, or knocking down a radio call box causes a tamper signal. A test signal is transmitted

automatically once a day, controlled by an internally set clock, or manually by service personnel. Batteries for modern radio call boxes are usually rechargeable. Full charge capacity operates the transmitter for six months. The battery may be continuously charged by a charger in the building or may be routinely removed for recharging and replaced with a fully charged battery.

3.10.4.6 Testing and Maintenance of Transmitters. Test manual and automatic transmitters quarterly. For efficiency, these tests may be combined with tests of circuits and other devices. The test includes initiating an alarm to cause the transmitter to actuate in its normal manner. For transmitters that have more than one mode of actuation, such as manual and electrical, test both modes. For radio frequency transmitters which transmit several types of signals, transmit each signal. Actuation of automatic fire alarm transmitters should result from the condition sensed by an initiating device rather than electrical or mechanical simulation at the transmitter. When several transmitters are located in one building, be certain not to overlook any transmitters during the tests.

3.10.4.7 Troubleshooting. Troubleshooting and other maintenance procedures for reversal (noncoded) and McCulloh (coded central station) transmitters are discussed in Section 3.4.1 under "Remote Signal Transmitters ." The material on the coded McCulloh fire alarm transmitter also applies to coded municipal and coded proprietary transmitter types. The coded multiplex and coded radio frequency transmitters vary considerably for the various manufacturers. Consult the manufacturer's information for troubleshooting these transmitters.

3.10.5 Signal Receiving Devices. Signal receiving devices are described in Chapter 2 and in Section 3.4.1.

3.10.5.1 Testing and Maintenance of Signal Receiving Devices. Test major base alarm system receiving equipment daily. Some local authorities require testing major equipment during each hour. Individual noncoded receiver modules are adequately tested if receipt of signals is noted during quarterly transmitter tests. Coded radio frequency type receivers are tested each time a transmitter sends its daily automatic test signal.

Daily tests of coded central station, municipal, and proprietary receiving equipment should include receipt of normal transmitted signals from one transmitter connected to each signaling circuit. Signals transmitted during routine servicing and testing of building alarm and fire protection equipment satisfy this requirement for the signaling circuits on which they occur.

Coded multiplex type receivers are in almost constant communication with the data gathering panels of the system. The interrogate/response action between the receiver and data gathering panels usually occurs one or more times a minute. Additional tests should be performed if recommended by individual equipment manufacturers at recommended intervals.

3.10.5.2 Troubleshooting. Follow the manufacturer's recommendations in troubleshooting receiver problems. Individual component maintenance and troubleshooting is described in Section 3.3 for relays, capacitors, diodes, resistors, and other components frequently found in receiving equipment.

3.10.6 Signal Recording Devices. Signal recording devices are described in Chapter 2 and in Section 3.4.1.

3.10.6.1 Testing and Maintenance of Signal Recording Devices. Test signal recording devices daily. An actual or simulated signal from a transmitter satisfies this requirement. The recording medium (paper tape in most cases) must move smoothly through the recorder. Printing should be dark enough so there is no trouble interpreting the information. Inspect ink ribbons for signs of wear.

Maintenance should also include the following steps.

1. Clean ink residue from idler rollers and working parts daily, if necessary.
2. Do not change adjustments except where necessary for proper operation and as recommended by the manufacturer.
3. Rewind rewound drive mechanisms as necessary. Check daily.
4. Maintain an adequate supply of paper tape. Replace expended rolls of tape with full rolls when tape on a roll drops below that necessary for three complete coded fire alarm signals. Maintain tape alignment to avoid breakage.
5. Manually advance ink ribbons on seldom used printers to avoid faint printing due to dried out ribbon.
6. Maintain time stamp settings to the proper time.

3.10.6.2 Troubleshooting. If printing or inked markings are not dark enough, replace ink ribbons or ball point type cartridges. Signs of ribbon wear may indicate that the ribbon is old, or ribbon movement is not smooth, or that the ribbon is not reversing at the end of each pass through the printer.

3.10.7 Power Supplies. Normal and emergency power supplies for base alarm system related equipment are described in Section 2.3.2.

3.10.7.1 Testing and Maintenance of Power Supplies. Other testing of base alarm system equipment provides for adequate testing of equipment power supplies. Operate engine driven generators weekly for 1 hour. During the one hour weekly running test, the generator load should be the same equipment usually driven by the generator under emergency conditions. After generator warmup, check temperature gauges for proper temperature control by thermostats. Check fuel supplies. Test automatic start features by shutting down the normal power sensed by the starting device. Perform other tests according to the generator manufacturer's instructions.

Check water levels for rechargeable cells weekly and add distilled water for any cells with low water levels. Wipe moisture from tops of cells; clean corroded terminals of lead acid cells with a wire brush and mild baking soda solution. Be careful not to spill cleaning solution on cell caps or into cells. Dry the terminals after cleaning and coat them with a thin film of protective lubricant recommended by the battery manufacturer. Terminal connections should be clean and tight.

Measure individual cell voltages and record them monthly so deteriorating cells can be discovered before there is a system malfunction. Perform equalize charging of battery according to battery and/or charger manufacturer's instructions for the particular application. To avoid possibly serious electrical shock during testing and cell cleaning, avoid touching earth ground and cell terminals simultaneously. Wear a rubber apron, gloves and goggles during these activities to avoid shock and chemical burns.

3.10.7.2 Troubleshooting. Follow equipment manufacturer's recommendations for troubleshooting emergency generator and battery charger problems. Failures are unlikely if recommended tests and maintenance are performed. When battery problems are suspected, perform routine cell measurements, inspect water level, and confirm that interconnections between cells are clean and tight. Cell measurements will help in locating cells which are below standard performance. Further inspection may reveal a maintenance deficiency. Replace cells which show inconsistent or substandard cell voltage after correction of maintenance deficiencies.

CHAPTER 3. SELF-STUDY QUESTIONS

Instructions: Select the correct answer(s) for each of the following questions.

Q3-1 To make servicing of fire alarm equipment as easy as possible, it is important to have the following reference materials readily available:

- a. A dictionary
- b. Schematic diagrams and manufacturer's data sheets
- c. The appropriate basic electronics repair manual
- d. A telephone book

Q3-2 The equipment manufacturer's customer service department:

- a. Is a place to contact only when all repair attempts fail.
- b. Should be called immediately when the equipment fails.
- c. Can tell you the equipment serial number if you describe the equipment.
- d. May be able to give helpful repair suggestions on the phone or send data sheets if you can give identifying model and serial numbers.

Q3-3 Large items of equipment, when in need of repair:

- a. Should be returned to the manufacturer as soon as possible.
- b. Should be repaired in place, if possible, to avoid the problems associated with removal and shipping.
- c. Visually are too complicated to even attempt to disassemble for inspection of components.
- d. Are usually easier to remove in one piece than to analyze and disassemble.

Q3-4 Relay contacts should be:

- a. Cleaned monthly with a burnishing tool.
- b. Adjusted with long nosed pliers when you think they are not operating properly.
- c. Burnished by moving the tool perpendicular to the normal contact wiping action.
- d. Maintained only when a symptom of a problem arises.

Q3-5 Resistors:

- a. Should be inspected for physical damage when a problem arises.
- b. Should be periodically inspected to make sure they are operating without overheating.
- c. Do not need replacement if their value has changed only 40% due to overheating.
- d. Can more easily be repaired than replaced.

Q3-6 Adjustable wire wound resistors:

- a. With a broken wire can usually be repaired with solder.
- b. Should be cleaned periodically with hydrochloric acid.
- c. Are often damaged by attempting adjustment before loosening the sliding band.
- d. Are cleaned most effectively if cleaned with alcohol while still hot from use.

Q3-7 Electrolytic capacitors:

- a. Are usually nonpolarized.
- b. Are immune to deterioration from disuse.
- c. Can be "formed" by applying voltage of the opposite polarity to that marked on the capacitor.
- d. None of the above.

Q3-8 To check individual components of a circuit with an ohmmeter, it is best to:

- a. Turn on power to the circuit.
- b. First disconnect wires which might affect readings.
- c. Use a high resistance scale to check values near zero.
- d. All of the above.

Q3-9 The usual function of a diode is to:

- a. Allow current flow in one direction.
- b. Provide high resistance to alternating current.
- c. Provide high resistance to direct current.
- d. To reverse the direction of direct current flow.

Q3-10 In checking an ordinary stepdown transformer with an ohmmeter:

- a. It may be necessary to disconnect 5 wires.
- b. There should be no continuity between primary and secondary windings.
- c. Measure primary and secondary voltages at the terminals.
- d. All of the above.

Q3-11 If a fuse has blown twice:

- a. Replace it with one of slightly higher current rating.
- b. Short circuit the fuse terminals and look for signs of overheating.
- c. Look for an electrical problem that could cause excessive current.
- d. None of the above.

Q3-12 Enclosed switches in alarm equipment should:

- a. Be disassembled, cleaned and lubricated quarterly.
- b. Not be operated routinely, because each switch only has a limited number of operations in its lifetime.
- c. Be operated during routine testing.
- d. None of the above.

Q3-13 Small DC motors, when not functioning properly, often require:

- a. Operation with reversed polarity for a few minutes.
- b. Disassembly and cleaning of the reduction gears.
- c. Replacement of brushes.
- d. All of the above.

Q3-14 Synchronous AC motors used in timing applications:

- a. Usually require no servicing other than brush replacement.
- b. May require lubrication of bearings with 10W-40 motor oil.
- c. Can usually be repaired by lightly sanding the commutator.
- d. None of the above.

Q3-15 Small universal AC/DC high speed motors are sometimes used:

- a. In vibrating horns.
- b. In timing applications.
- c. In continuous duty applications because of the absence of brushes and commutator.
- d. All of the above.

Q3-16 The following visual indicators cannot be checked with an ohmmeter:

- a. Incandescent (tungsten filament) lamps.
- b. Light emitting diodes (LEDs).
- c. Neon lamps.
- d. None of the above.

Q3-17 The most frequent problems with interconnecting wiring between control units and initiating and indicating devices occur:

- a. At junction boxes.
- b. At the wire terminations.
- c. In the long straight sections of conduit.
- d. At right angle bends.

Q3-18 In checking a voltmeter, you notice that the meter always returns to a reading just to the right of zero when the voltage is zero. Tapping the 123.8r lens causes the needle to vibrate and settle to the same reading. The most likely problem is:

- a. Friction in the bearings.
- b. An obstruction to normal meter deflection.
- c. The need for battery replacement.
- d. The need for zero adjustment.

Q3-19 To check an am123.8r, the standard ammeter for comparison readings should not be:

- a. Connected in series with the meter being tested.
- b. Connected in parallel with the 123.8r being checked.
- c. Similar in scale to the meter being checked.
- d. More accurate than the meter being checked.

- Q3-20 The risk of personal injury from electrical shock is greatest in servicing:
- a. Line voltage control units.
 - b. 12-VDC control units.
 - c. 48-VDC control units.
 - d. 12-VAC control units.
- Q3-21 The current cut-off device in a line voltage control unit acts as a:
- a. Relay and a buzzer.
 - b. Resistor and a relay.
 - c. Relay coil and contact.
 - d. Circuit breaker and timer.
- Q3-22 The replaceable modules in a modular control unit may:
- a. Control audible signal devices.
 - b. Transfer power from the commercial source to standby.
 - c. Provide a reversing output voltage for remote signaling.
 - d. All of the above.
- Q3-23 In a coded building alarm system, extra momentary sounds from the audible signal devices may be caused by:
- a. A loose wire supplying power to the coder.
 - b. Irregular speed of the coder drive motor.
 - c. Incomplete removal of code wheel teeth.
 - d. All of the above.
- Q3-24 If a paper tape register continues to run long after a coded signal is complete, the defect may be:
- a. A defective capacitor in the timing circuit.
 - b. Residual magnetism in the timing relay.
 - c. Solenoid shaft wear.
 - d. A short circuited diode across the timing relay coil.
- Q3-25 A reversal signal transmitter consists of:
- a. A motor, a code wheel, and contacts.
 - b. A digital device which transmits a digital code.
 - c. A relay and a power supply.
 - d. None of the above.
- Q3-26 If a properly adjusted McCulloh transmitter does not produce readable signals at the receiver, the cause may be:
- a. Excessive capacitance.
 - b. The spacing of the code wheel teeth.
 - c. A lag in relay operation at the receiver.
 - d. All of the above.

Q3-27 An open fault in a power circuit usually causes:

- a. A blown fuse or circuit breaker.
- b. An indication of power failure.
- c. A low voltage DC alarm system to become inoperative.
- d. None of the above.

Q3-28 An open circuit fault in an unsupervised initiating circuit may cause:

- a. The circuit to become inactive.
- b. A trouble signal at the control unit.
- c. A false alarm.
- d. None of the above.

Q3-29 A short circuit fault in a series normally closed initiating circuit causes:

- a. A false alarm.
- b. A trouble signal.
- c. The circuit to become inactive.
- d. The circuit beyond the fault to become inactive.

Q3-30 Manual fire alarm devices should not be painted because:

- a. Paint interferes with movement of working parts.
- b. The paint may cause a short circuit.
- c. The paint used may not be U.L. listed.
- d. All of the above.

Q3-31 For a practical periodic test of the electrical function of a manual device, it is necessary to:

- a. Break the glass or fiber retainer.
- b. Remove the device from the wall to short circuit the terminals on the back.
- c. Open the device with an appropriate tool.
- d. None of the above.

Q3-32 Automatic fire detectors must not be:

- a. Tested.
- b. Painted.
- c. Touched with bare hands.
- d. None of the above.

Q3-33 Fixed temperature detectors with fusible elements should be heat tested:

- a. Every 5 years.
- b. Only when an inspection shows a possible defect.
- c. Every year.
- d. Quarterly.

Q3-34 Rate compensated detectors are:

- a. A type of smoke detector.
- b. Visually checked for actuation.
- c. Reusable.
- d. Similar in appearance to a rectangular metal box.

Q3-35 Rate of rise detectors usually operate on the principle of:

- a. Differential expansion of metals with temperature.
- b. Increasing air pressure with increasing temperature.
- c. Generation of electricity at a bond of dissimilar metals.
- d. Melting of a eutectic alloy at high temperature.

Q3-36 A thermistor type heat detector operates on the principle of:

- a. Melting plastic allowing two wires to touch.
- b. Pneumatic tubing causing contacts to close when heated.
- c. DC voltage generated by a thermocouple when heated.
- d. None of the above.

Q3-37 After installing a new fusible element heat detector, test it immediately by:

- a. Applying heat slowly with a lamp or hot air gun.
- b. Removing the fusible element if it is removable.
- c. Rubbing the detector vigorously with your hand.
- d. Tapping it lightly with a screwdriver handle.

Q3-38 Line type rate of rise detectors may make use of:

- a. Rosettes.
- b. Thermoplastic material.
- c. Differential expansion of metals.
- d. None of the above.

Q3-39 Photoelectric smoke detectors may operate on the principle of:

- a. Light obscuration by smoke.
- b. Light reflection by smoke.
- c. Light being blocked or partially blocked by smoke.
- d. All of the above.

Q3-40 Ionization smoke detectors can detect smoke by:

- a. The ions in the smoke causing an increased current between two high voltage plates.
- b. A radioactive source ionizing the smoke causing an increase in current.
- c. The solid smoke particles interfering with current flow in air ionized by a radioactive source.
- d. The obfuscation of reticular ionization.

Q3-41 The main difference between spot type and duct type smoke detectors is:

- a. The arrangement of electronic parts.
- b. The method of powering the detector.
- c. The method of moving smoke into the detector.
- d. All of the above.

Q3-42 A spot type photoelectric smoke detector may need:

- a. Periodic cleaning of the smoke chamber with detergent.
- b. Occasional removal of dust with low pressure air.
- c. Replacement of an LED at the job site.
- d. Recovery in bright light after cleaning.

Q3-43 Beam type smoke detectors may require such servicing as:

- a. Replacement of a light source LED at the job site.
- b. Cleaning of lenses and mirrors.
- c. Immersion of filters in mild hydrochloric acid.
- d. All of the above.

Q3-44 Optical flame detectors can distinguish flame from nonflame light sources by using:

- a. Flicker discrimination.
- b. The optical integrity lamp inside the detector.
- c. Precision spectral analyzing circuits in combination with flicker frequency validation.
- d. All of the above.

Q3-45 Sprinkler waterflow is often detected by:

- a. An increase in pressure.
- b. A drop in pressure.
- c. The waterflow causing mechanical movement of a vane inside the pipe.
- d. All of the above.

Q3-46 Valve position switches cause a supervisory signal when:

- a. The valve handle is operated two turns.
- b. The valve handle is operated beyond 20% of its range from its normal position.
- c. A plunger or lever moves out of a notch in the valve stem.
- d. All of the above.

Q3-47 Pump supervisory signals usually are initiated by:

- a. Sophisticated sensors in the controller cabinet.
- b. Heat sensors in the controller cabinet.
- c. Relay contacts in the controller cabinet.
- d. None of the above.

CHAPTER 4. AUTOMATIC SPRINKLER AND STANDPIPE SYSTEMS

4.1 AUTOMATIC SPRINKLER SYSTEMS. Automatic sprinkler systems automatically distribute water upon a fire in sufficient quantity either to extinguish it entirely or to prevent its spread. All sprinkler systems have three basic components: (1) a water supply, (2) a piping network to carry the water, and (3) sprinklers which distribute the water.

4.1.1 Sprinklers. Sprinklers are essentially nozzles placed at intervals along the piping network to distribute a uniform pattern of water on the area being protected. To attain maximum efficiency, the stream of water must be broken into droplets. A deflector, which is a part of the frame of the sprinkler, breaks up the water.

4.1.1.1 Automatic Sprinklers. Automatic sprinklers are listed and approved by certified testing laboratories for specific applications based on orifice size, deflector design, frame finish, temperature rating, and response time index.

- Orifice Size. Sprinklers have orifice diameters ranging from 0.25 to 0.70 inches.
- Deflector Design. Deflector designs give different patterns of water distribution and allow the sprinkler to be placed in various positions, e.g. , upright, pendent or sidewall (Figure 4-1). Deflector design also dictates the droplet size of the water spray.
- Frame Finish. Sprinkler frames may be plated for aesthetic purposes or they may be coated for protection purposes. For example, sprinklers intended for use in corrosive atmospheres are either lead or wax coated.

- Temperature Rating. Automatic sprinklers are normally held closed by heat sensitive elements which press down on a cap over the sprinkler orifice and are anchored by the

frame of the sprinkler. The heat sensitive SPRINKLER DEFLECTOR STYLE elements are designed to release at different temperatures, depending upon the application. Sprinklers are color coded to identify the range of temperature rating of the fusible element (Table 4-1). Color identification is not required for plated sprinklers, ceiling sprinklers, or similar decorative types.

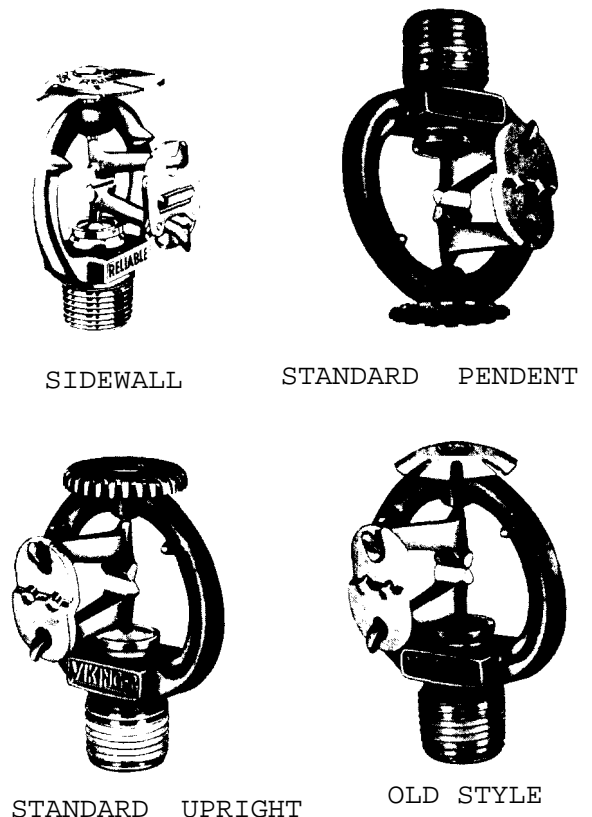


FIGURE 4-1

- Response Time Index(RTI). The RTI is a measure of the sensitivity of the sprinkler head. A typical range of RTI for residential sprinklers is 30-60 (ft-sec)^{1/2} and for commercial sprinklers is 150-600 (ft-sec)^{1/2}.

TABLE 4-1
SPRINKLER TEMPERATURE RATINGS

MAXIMUM AMBIENT CEILING TEMPERATURE (°F)	TEMPERATURE RATING (°F)	TEMPERATURE CLASSIFICATION	SPRINKLER COLOR CODE
100	135 to 170	Ordinary	Uncolored
150	175 to 225	Intermediate	White
225	250 to 300	High	Blue
300	325 to 375	Extra High	Red
375	400 to 475	Very Extra High	Green
475	500 to 575	Ultra High	Orange

There are basically four types of release mechanisms for automatic sprinklers : (1) fusible link, (2) frangible bulb, (3) frangible pellet, and (4) on-off element.

- Fusible Link Sprinklers. The fusible link automatic sprinkler (Figure 4-2) is kept in the closed position by a two-piece link held together by a solder with a predetermined melting point. The soldered link is between two levers which are arranged between the cap, over the orifice and the top of the sprinkler frame. When the solder in the fusible link melts, the levers pull the two-piece link apart and flies away from the sprinkler. This allows the pressure in the piping network to push the cap off the orifice and the sprinkler to discharge water.

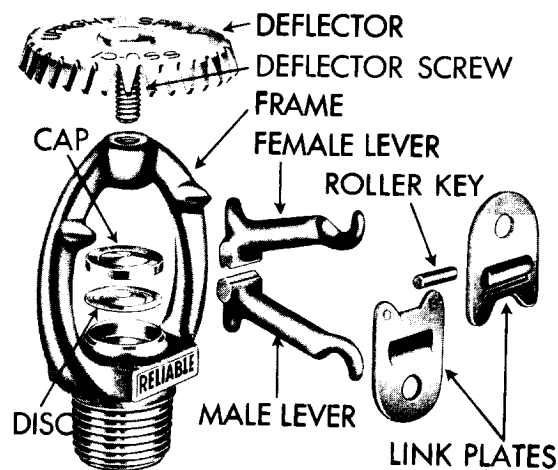


FIGURE 4-2
FUSIBLE LINK AUTOMATIC SPRINKLER

- **Frangible Bulb Sprinklers.** The frangible bulb sprinkler (Figure 4-3) has a small bulb made of glass between the orifice cap and sprinkler frame. This bulb is partially filled with a liquid. The rest of the space in the bulb is occupied by an air bubble. In a fire, the heat causes the liquid to expand and compress the air bubble. As the air bubble compresses, the pressure increases inside the bulb causing the bulb to shatter and allowing the pressure in the piping network to push off the orifice cap.
- **Frangible Pellet Sprinkler.** The frangible pellet sprinkler (Figure 4-4) has a rod between the orifice cap and sprinkler frame. The rod is held in place by a pellet of solder under compression. When the solder melts the rod moves out of the way of the orifice cap which is pushed off by the water pressure in the piping network.
- **On-Off Sprinkler.** On-off Sprinklers are capable of individually terminating water discharge. They operate using a hi-metallic element or wax motor.

The hi-metallic element sprinkler (Figure 4-5) uses a disc made of two distinct metals as a heat sensitive element. When the sprinkler is off, the disc maintains pressure on a piston assembly. When the temperature reaches the rating set point, the disc flexes and opens, releasing pressure on the piston assembly and allowing a small amount of water to bleed out of the piston chamber faster than it can be replaced through a restrictor. The pressure from the water in the piping system pushes the piston down and allows the sprinkler **to** discharge water. When the temperature of the sensitive element is reduced, the element returns to its normal position and allows water to pass through the restrictor, filling the piston chamber and forcing the piston into the waterway which stops the flow of water from the sprinkler.

The wax motor sprinkler has a fusible link as well as a small wax motor. Following the release of the fusible link, water discharge occurs only after the special wax melts. Melting of the wax results in a force being applied to a piston which opens a cam to permit water flow. When the wax solidifies upon cooling, the piston returns to its original position, closing the cam. This type of on-off head must be replaced after operation.

4.1.1.2 Dry Pendent Sprinkler. A dry pendent sprinkler (Figure 4-6) is used when pendent sprinklers must be placed on dry pipe systems. Dry pendent sprinkler also may be installed in wet pipe systems when the area to be protected is subject to freezing and the piping network is in a heated area. (See Section 4.1.2 for a description of dry pipe and wet pipe systems.) The dry pendent sprinkler is a standard automatic sprinkler fitted with a tube within an attached pipe. The tube holds the water sealing elements in place against a watertight seal at the top of the pipe. When the sprinkler is activated, the tube drops down to a predetermined position and releases the elements through the tube and out the open sprinkler.

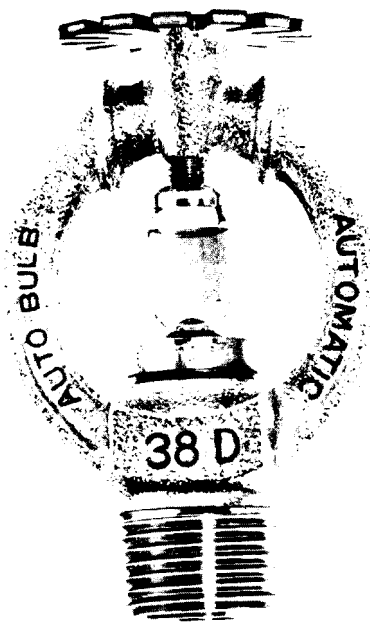
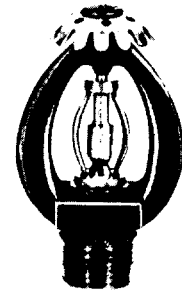


FIGURE 4-3
FRANGIBLE BULB AUTOMATIC SPRINKLER



SIDEWALL SPRAY SPRINKLER
MODEL E



UPRIGHT SPRAY SPRINKLER
MODEL E

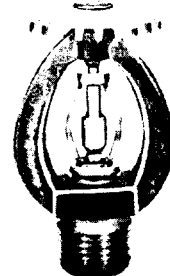
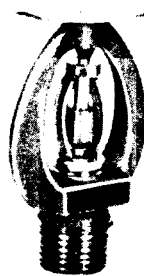


FIGURE 4-4
FRANGIBLE PELLETT AUTOMATIC SPRINKLER

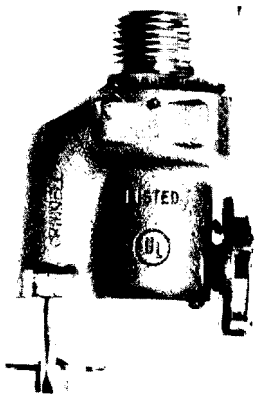


FIGURE 4-5
BI-METALLIC ELEMENT AUTOMATIC
SPRINKLER

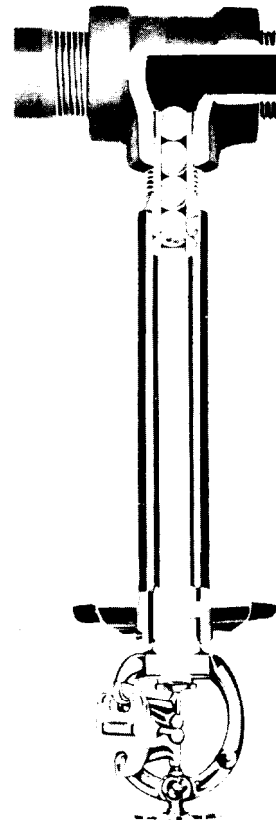


FIGURE 4-6
DRY PENDENT AUTOMATIC SPRINKLER

4.1.1.3 Open Sprinklers.

Open sprinklers (Figure 4-7) consist of only a sprinkler frame and deflector. These are used on special sprinkler systems, such as deluge or rapid reaction systems.

4.1.1.4 Water Spray Nozzles.

Water spray nozzles (Figure 4-8) are used for special application of water in various patterns; e.g. , wide or narrow angle, long throw or flat patterns. The different patterns may be achieved by either internal or external deflection of the water stream, depending upon the type of nozzle.

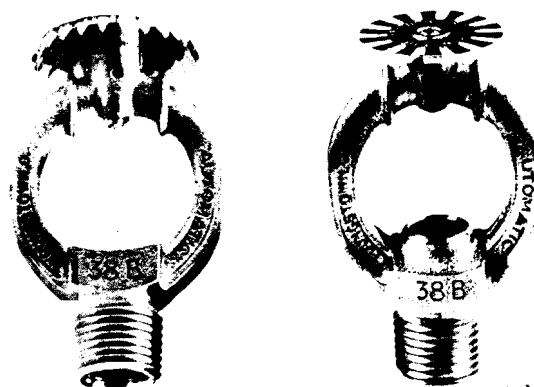


FIGURE 4-7
OPEN SPRINKLERS



FIGURE 4-8
WATER SPRAY NOZZLES

4.1.2 Types of Sprinkler Systems.

4.1.2.1 Wet Pipe System. The wet pipe sprinkler system is the most common type. This system has automatic sprinklers attached to a piping network with water under pressure at all times. When a fire occurs, individual sprinklers are actuated by heat and water flows from the sprinklers immediately. A wet pipe system is generally used when there is no danger of the water in the pipes freezing or when there are no special conditions that require a special purpose sprinkler system. The wet pipe sprinkler system may have an alarm check valve (Figures 4-9 and 4-10). This device is used to maintain a constant pressure on the sprinkler piping network "downstream" of the valve.

When there is a fire, the flowing water causes the clapper assembly inside the alarm check valve to open and allows a portion of the water to flow through a port in the alarm check valve which is, in turn, connected to an alarm device. To prevent false alarms from water surges, a retard chamber is usually placed in the piping between the alarm check valve and the alarm device,

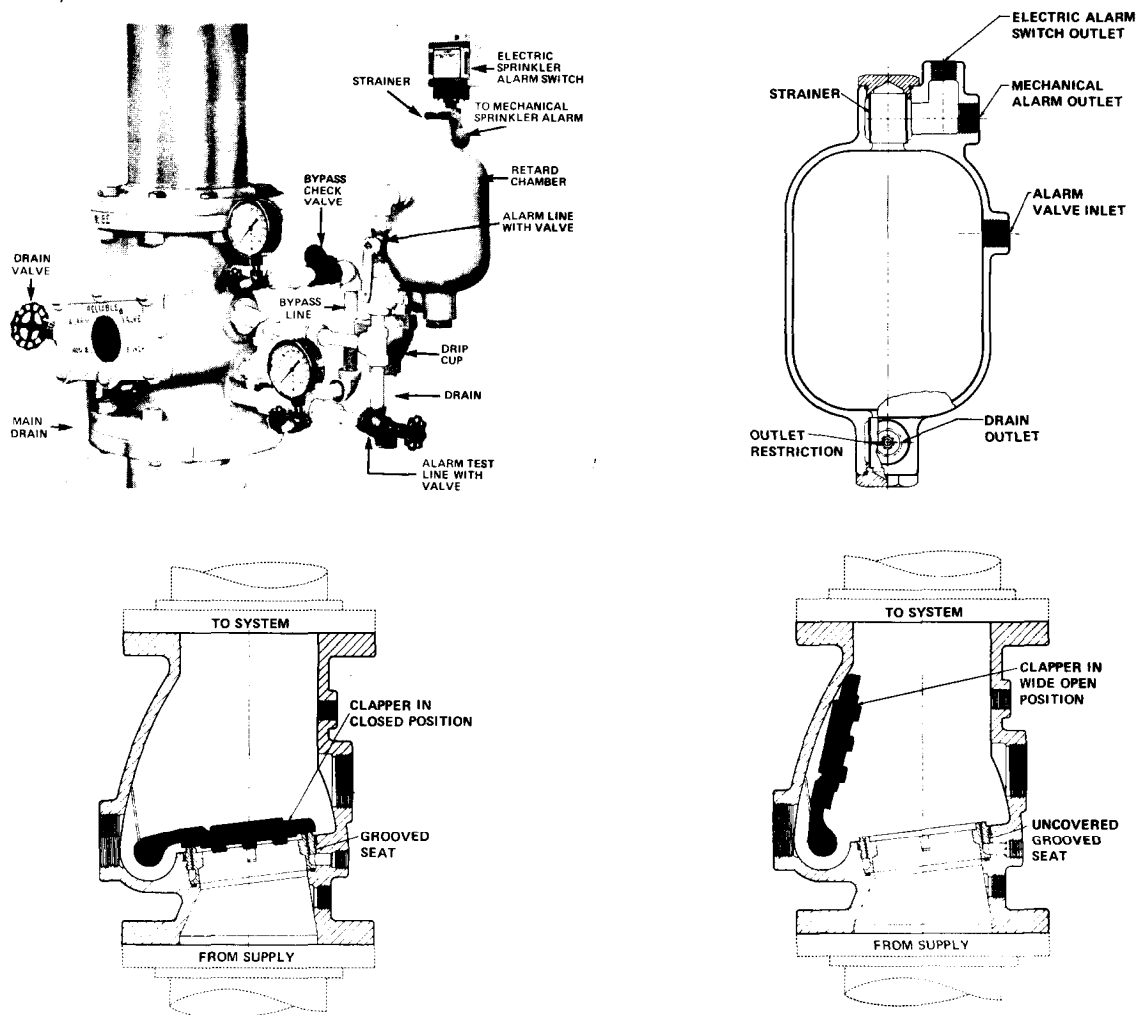


FIGURE 4-9
ALARM CHECK VALVE

4.1.2.2 Dry Pipe System. In a dry pipe system, the pipes normally contain either air or nitrogen under pressure instead of water. Dry pipe systems are used in areas where water in the pipes would be subject to freezing, such as unheated areas or cold storage spaces.

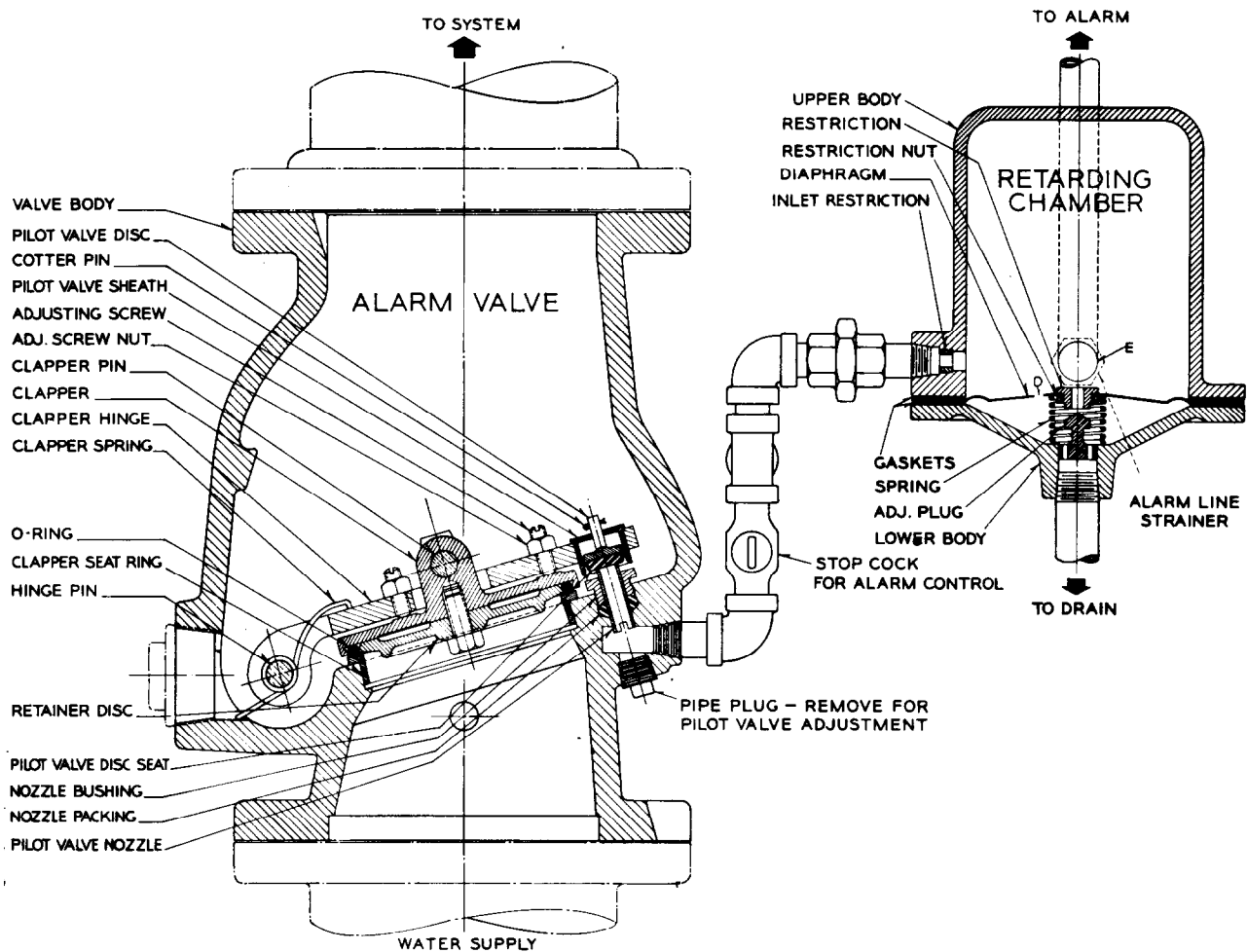


FIGURE 4-10
ALARM CHECK VALVE (SECTION)

A dry pipe valve (Figure 4-11) acts as a control between the water supply and the air under pressure in the piping network. The dry pipe valve must be in a heated enclosure because pressurized water is at the underside of the dry pipe valve. A small amount of water, called priming water, is also inside the dry pipe valve itself. This water is to insure a tight seal of the clapper and to keep the rubber gaskets pliable.

The valve is usually made so that a moderate air pressure holds back a much greater water pressure.

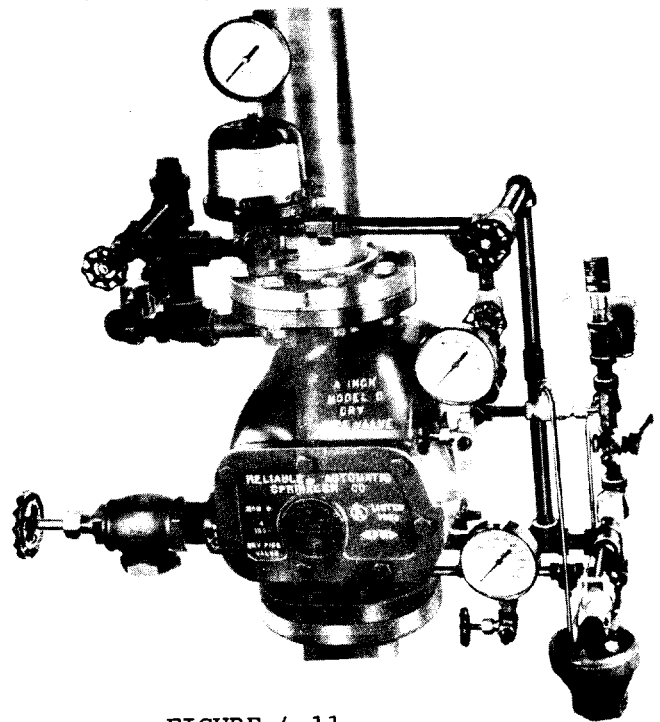


FIGURE 4-11
DRY PIPE VALVE

There are four types of dry pipe valves:

- Differential Dry Pipe Valve. The differential dry pipe valve (Figure 4-12) has a large clapper (air side) which bears directly on a smaller clapper (water side). The differential between the areas of the two clappers is approximately 6 to 1. Therefore, relatively low air pressure can hold back a much larger water pressure. For example, 20 psi air pressure can withhold 120 psi water pressure. To eliminate an accidental trip of the valve and false alarms, air pressure should be at least 20 psi greater than the calculated trip pressure of the dry pipe valve, based on the highest normal water pressure of the supply system.

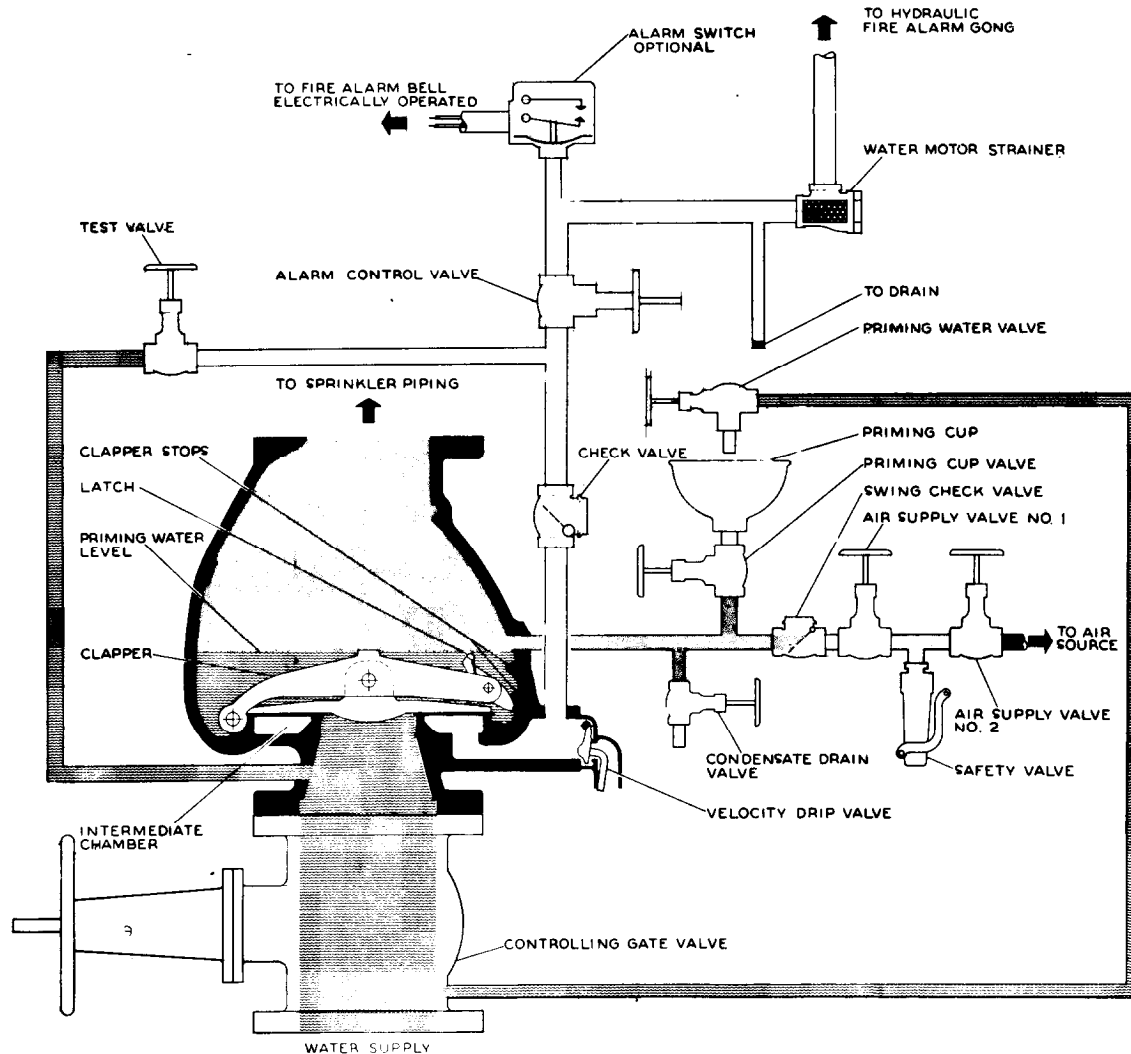


FIGURE 4-12
DIFFERENTIAL DRY PIPE VALVE

When there is a fire, the heat actuates the sprinkler(s) and allows air to escape from the piping network, reducing the system air pressure. As the system air pressure is reduced, the differential is destroyed and the water pressure below the dry pipe valve opens the clapper, allowing water to flow through the piping network to the open sprinkler(s).

Differential dry pipe systems have an inherent time delay between the actuation of a sprinkler and the application of water to the fire. This delay

is due to the time needed to bleed the air from the piping network and deliver water from the dry pipe valve to the opened sprinkler(s). The time delay can be shortened by adding the accelerator or the exhaust as a quick opening device to the dry pipe system.

- a. Accelerator. The accelerator (Figure 4-13) allows air from the system's piping to enter the intermediate chamber in the dry pipe valve, destroying the differential, and opening the clapper.
- b. Exhauster. The exhauster (Figure 4-14) opens and exhausts air from the piping system faster than through the sprinklers, destroying the differential sooner.

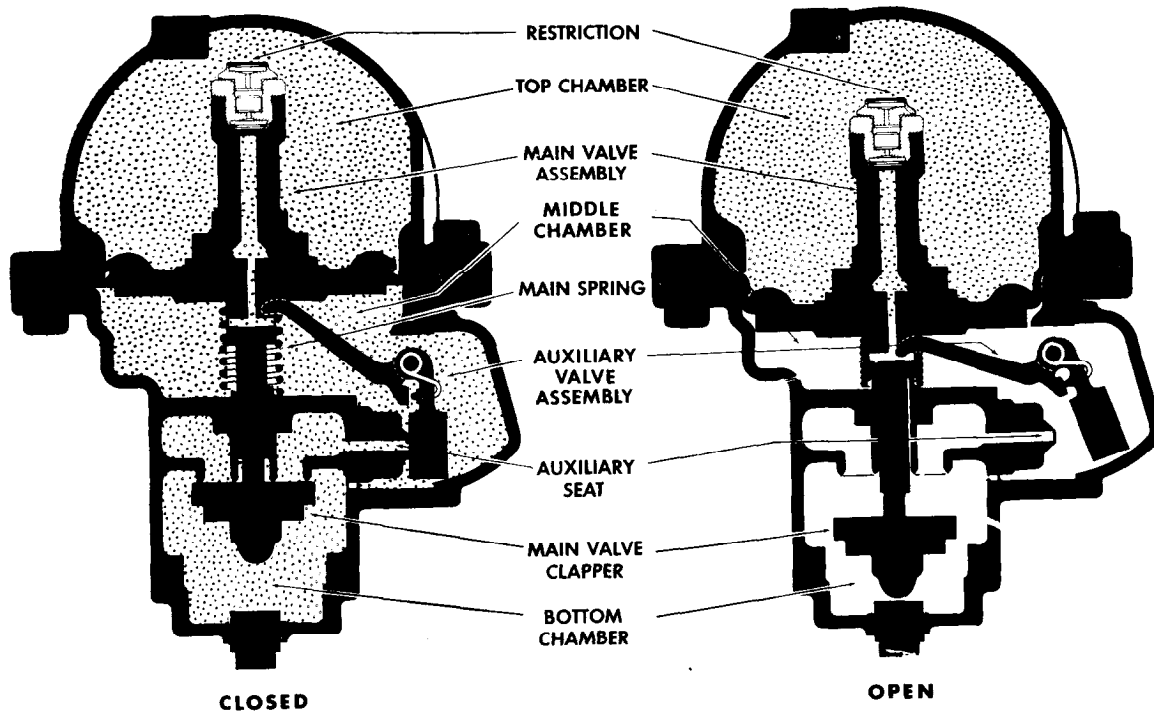


FIGURE 4-13
DRY PIPE SYSTEM ACCELERATOR

- Low-Differential Dry Pipe Valve. Occasionally, the water supply to dry pipe valves has debris. With a differential dry pipe valve (Figure 4-15), the high velocity of water entering the system when the valve trips can carry the debris into the system and may plug the system piping or the sprinklers. If debris in the water is a problem, the low-differential dry pipe valve may be useful.

The clapper in the low-differential dry pipe valve is only slightly larger on the air side than on the water side and the air pressure in the system is maintained approximately 15 to 20 psi greater than the water pressure. Because the sprinkler system piping contains air pressure about equal to the water pressure, only a slight amount of water is diverted into the branch lines which do not have operated sprinklers after the dry pipe valve opens.

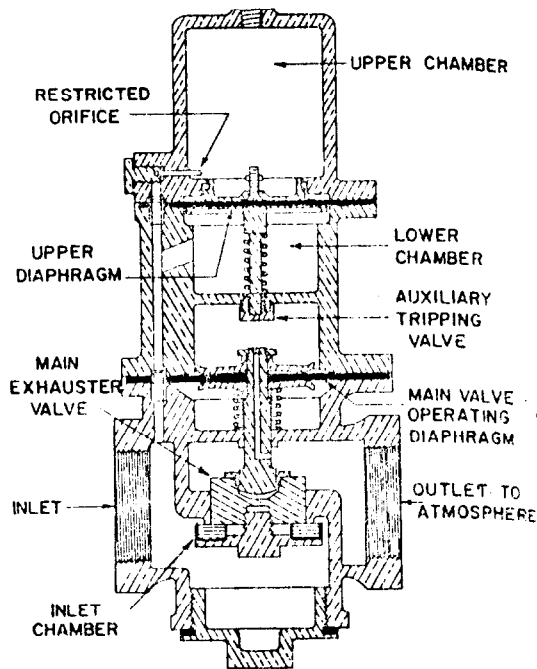


FIGURE 4-14
DRY PIPE SYSTEM EXHAUSTER

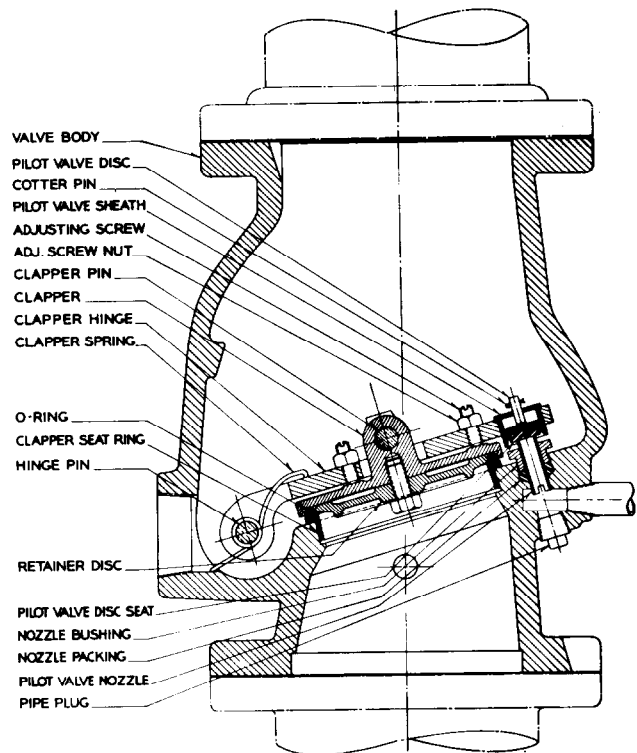


FIGURE 4-15
LOW DIFFERENTIAL DRY PIPE VALVE

With either a differential or low-differential dry pipe valve, an automatic air maintenance device (Figure 4-16) must be used to maintain air pressure and prevent accidentally tripping the dry pipe valve. Also, an automatic drain or high-water-level alarm is required for the priming water level so the water does not accumulate. (If there is too much water, the dry pipe valve cannot operate.)

- Mechanical or Latched-Clapper Dry Pipe Valve. The mechanical dry pipe valve has system air pressure against a small disc, diaphragm, or clapper (Figure 4-17). An arrangement of levers, links, and latches on the valve clapper provide the closing force on the water clapper.
- Auxiliary Dry Pipe or Air Check Valve. An auxiliary dry pipe valve or air check valve system may be used when unheated areas have 20 or more sprinklers, or are located remote from the water supply connection to the building. These valves operate the same as the standard dry pipe valve except an alarm device is not necessarily provided since the alarm is actuated by waterflow in the wet pipe system.

4.1.2.3 Antifreeze Systems. Occasionally, buildings protected by wet pipe sprinkler systems have small areas which are subject to freezing. If this area requires twenty sprinklers or less, an antifreeze system may be used (Figure 4-18). A check valve or backflow prevention device must be required to prevent contamination of a potable water system by the antifreeze solution. The antifreeze system uses an antifreeze solution, generally consisting of water and a water soluble liquid, such as glycerin or an alcohol glycol with a high flash point and high boiling point. The proportions specified in Table 4-2 give the noted reduction in freezing temperature without producing a combustible mixture.

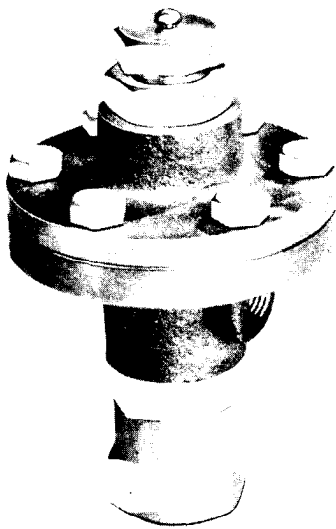
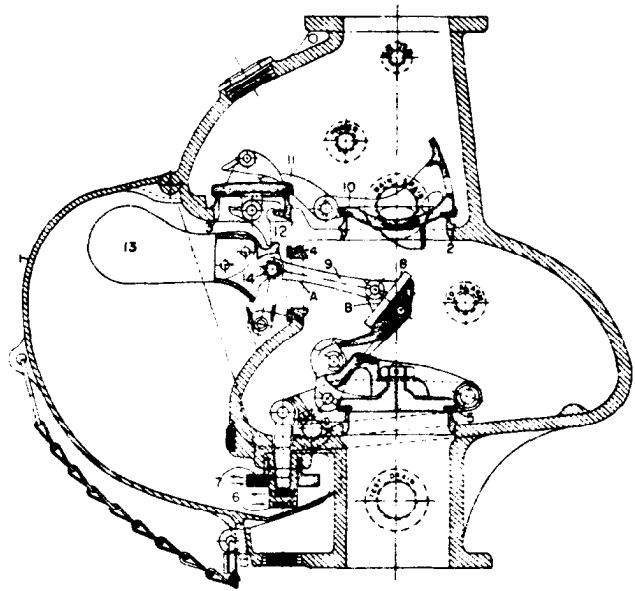


FIGURE 4-16
AIR PRESSURE MAINTENANCE DEVICE



- | | |
|--------------------------------|------------------------------|
| 1. Ball weight cover | 8. Intermediate clapper |
| 2. Water and air clapper seats | 9. Intermediate clapper link |
| 3. Auxiliary clapper seat | 10. Air clapper |
| 4. Intermediate clapper seat | 11. Auxiliary clapper |
| 5. Water clapper | 12. Trigger |
| 6. Adjusting nut | 13. Ball weight |
| 7. Adjusting screw lock nut | 14. Ball weight pin |

FIGURE 4-17
MECHANICAL DRY PIPE VALVE

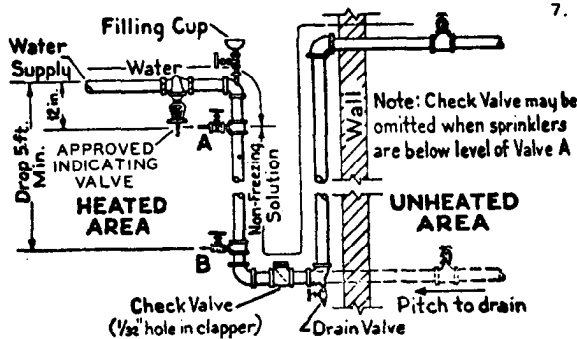


FIGURE 4-18
ANTIFREEZE SYSTEM

In systems which have connections to potable water supplies, do not use antifreeze solutions other than chemically pure glycerin (U.S. Pharmacopoeia 96.5% grade) or propylene glycol, even with backflow prevention devices included.

4.1.2.4 Water Deluge Systems. A water deluge system (Figure 4-19) is used where there is an extra hazard, such as areas where flammable liquids or propellants are handled or stored, or where there is a possibility that a fire might grow faster than ordinary automatic sprinklers can control. The systems are also often used in aircraft hangars where ceilings are unusually high and where drafts may deflect the direct rise of heat so that ordinary sprinklers directly over the fire would not open promptly but others, at some distance away, might open without having any effect on the fire.

TABLE 4-2
ANTIFREEZE SOLUTIONS

To Be Used if Public water Is Connected to Sprinklers

MATERIAL	SOLUTION (By VOLUME)	SPEC. GRAV. AT 60°F	FREEZING POINT 'F
Glycerine	50% Water	1.133	-15
C.P. or U.S. P. Grade*	40% Water	1.151	-22
	30% Water	1.165	-40
	Hydrometer Scale 1.000 to 1.200		
Propylene Glycol	70% Water	1.027	+ 9
	60% Water	1.034	- 6
	50% Water	1.041	-26
	40% Water	1.045	-60
	Hydrometer Scale 1.000 to 1.120 (Subdivisions 0.002)		

Suitable for Use if Public Water Is Not Connected to Sprinklers

Diethylene Glycol	50% Water	1.078	-13
	45% Water	1.081	-27
	40% Water	1.086	-42
	Hydrometer Scale 1.000 to 1.120 (Subdivisions 0.002)		
Ethylene Glycol	61% Water	1.056	-10
	56% Water	1.063	-20
	51% Water	1.069	-30
	47% Water	1.073	-40
	Hydrometer Scale 1.000 to 1.120 (Subdivisions 0.002)		
Calcium Chloride	Lb CaCl ₂ per		
80% "Flake" **	gal of Water		
Fire Protection Grade	2.83	1.183	0
Add corrosion inhibitor	3.38	1.212	-10
of sodium bichromate	3.89	1.237	-20
1/4 oz. per gal. water	4.37	1.258	-30
	4.73	1.274	-40
	4.93	1.283	-50

*

C.P. - Chemically Pure

U.S. P. - United States Pharmacopoeia 96.5%

**Free from magnesium chloride and other impurities

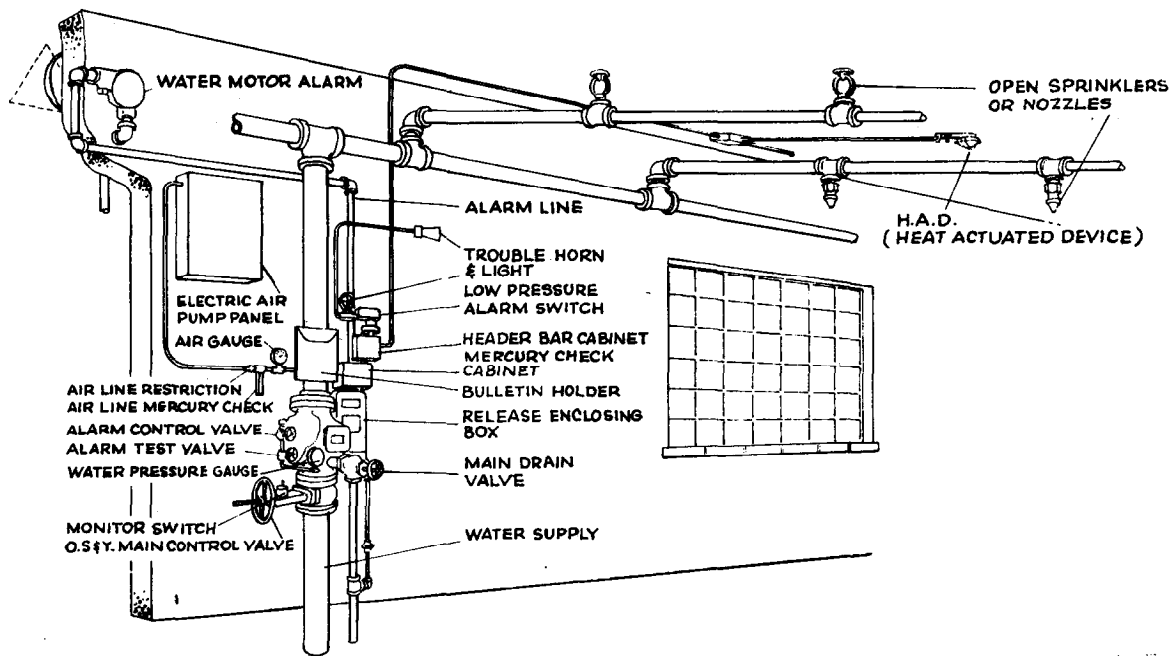


FIGURE 4-19
DELUGE SYSTEM

In the water deluge system, all sprinklers connected to the piping network are open and the water supply is controlled by a water deluge valve (Figures 4-20 and 4-21). The deluge valve remains closed until a fire is detected. Fire protection systems can be operated either manually or automatically. Automatic operation occurs upon a signal generated by a fire detecting device. This signal can be either mechanical or electrical.

Mechanical types of detection are pneumatic or hydraulic and are described below. Electrical devices are described in the section on associated alarm systems for each type of system. One of the most common types of detection systems, used with a mechanical release, is based on the principle that heated air expands. This system uses an air tight, hollow chamber, called a heat actuating device (HAD), which is usually made of brass. Its purpose is to absorb the heat from a fire and, in turn, heat the air inside the chamber. As the air is being heated, an increase in pressure is created. This pressure increase is conveyed by 1/8-inch tubing from the heat detecting devices to the release mechanism. Inside the release mechanism, a diaphragm is connected to a system of levers. Also, ahead of the diaphragm is a smaller vent which acts as a compensating device for normal temperature fluctuations. The 1/8-inch tubing is connected between the vent and the diaphragm.

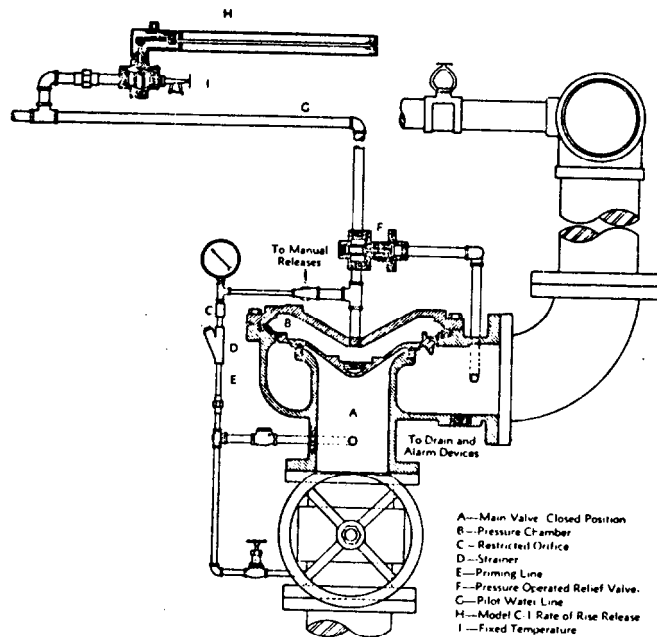


FIGURE 4-20
 DELUGE VALVE (VIKING MODEL D-4)

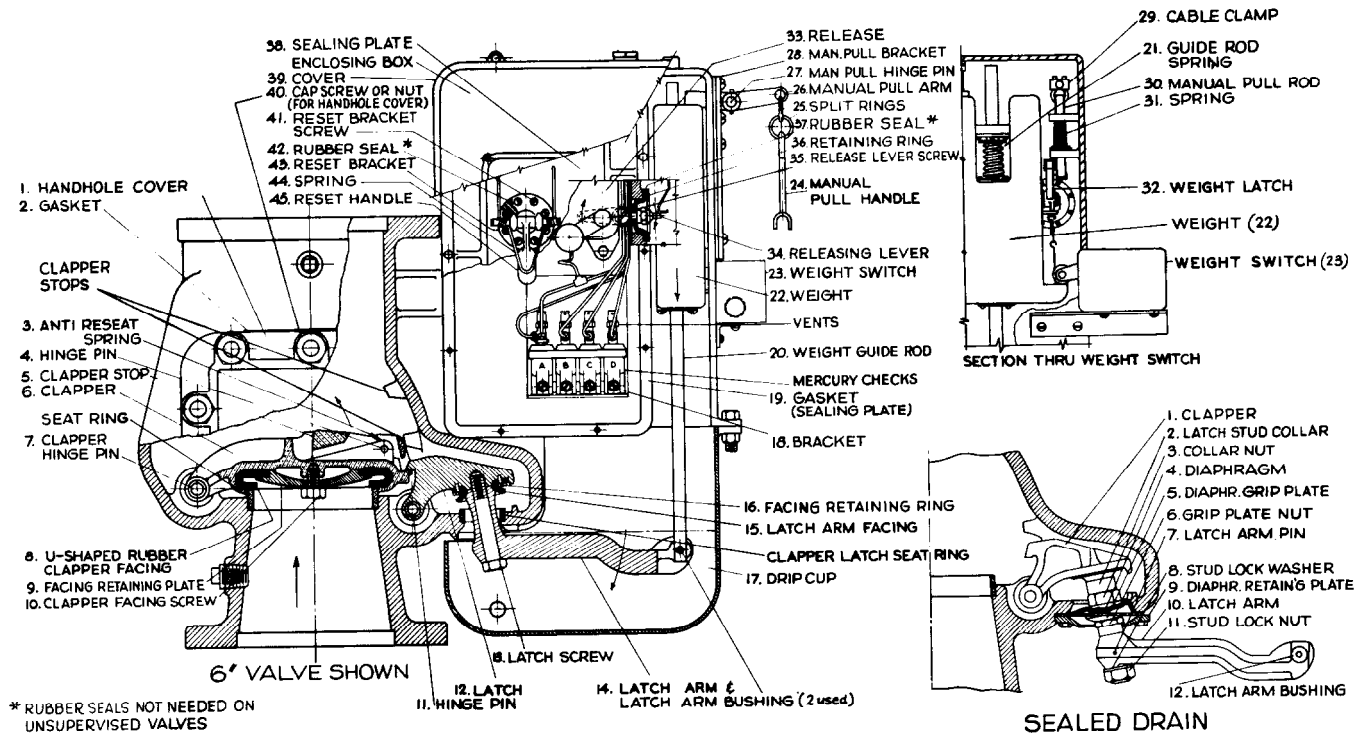


FIGURE 4-21
 DELUGE VALVE (AUTOMATIC SPRINKLER MODEL C)

During a fire, the heat produces pressures which exceed the bleeding capacity of the vent. When this happens, the diaphragm moves and causes the levers to operate, mechanically activating the system (Figure 4-22). As more HADs are attached to the detection system, the pressures developed by a fire in the detectors near the fire would be absorbed by the detectors located outside of the fire area, impeding operation. To eliminate this adverse

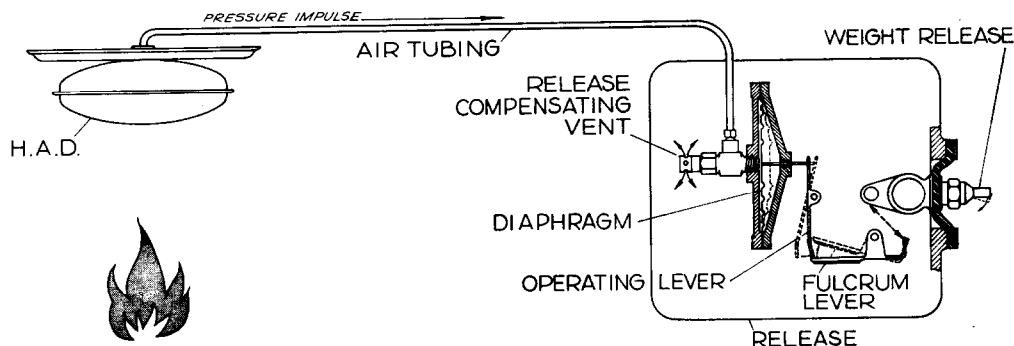


FIGURE 4-22
RATE OF RISE DETECTION COMPONENTS

feature, detectors are divided into groups of limited numbers. Each group has a separate line of air tubing connected to the release mechanism and is separated from other groups by a mercury check. Each mercury check has its own individual pressure setting and compensating vent (Figure 4-23). When pressure from the detection system presses against the column of mercury in the inlet well of the check, it pushes the mercury out of the way and allows the pressure to pass through the manifold passage to the diaphragm. The pressure is prevented from entering the tubing from other groups of detectors by the mercury in the wells of the other checks. Overcoming the pressure from the outlet side requires at least twice the pressure than would be required at the inlet side.

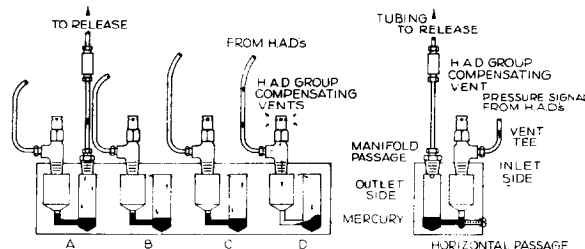
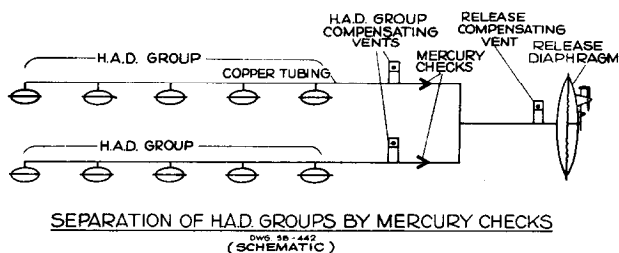


FIGURE 4-23
SEPARATION OF H.A.D. GROUPS BY MERCURY CHECKS

Another type of mechanical detection system uses fixed temperature detection devices which are standard automatic sprinklers. This system is called a pilot heat system and may be operated either pneumatically, with air or other gases, or hydraulically, with water.

The pneumatic system uses a 1/2-inch air line which is attached directly to the enclosing box of the release mechanism. Inside the enclosing box is one or two HAD's which are connected to the compensating vent on the diaphragm. The enclosing box, the pilot line, and the heat detectors are all at the same pressure, which is usually 8 psig. In a fire, the heat actuates one or more sprinklers. This causes the pressure in the pilot line and enclosing box to suddenly drop. The pressure in the heat detectors

cannot escape fast enough through the compensating vent and therefore presses on the diaphragm which trips the release mechanism.

Manufacturers use a wide variety of mechanical, pneumatic, hydraulic, and electrical devices for fire detection and, in general, each manufacturer provides his own particular complete combination of fire detection, water control valve release, and supervisory equipment. Check manufacturer's data for specific details.

Deluge valves have a clapper assembly inside the valve to prevent water from entering the piping network downstream of the valve. The clapper of the deluge valve is held closed either mechanically or pneumatically, depending on the type of deluge valve. When a fire occurs the fire detecting device transmits a signal to the deluge valve which causes the clapper to open and allows water to flow simultaneously from all sprinklers on the piping network. The deluge system, similar to the dry pipe system, has a time delay between detection and discharge of water, due to the time required to operate the valve and fill the piping network with water.

To reduce the delay, the deluge system may be pre-primed by providing water in the piping network downstream of the deluge valve. To prevent the water from escaping from the open sprinklers, pre-prime plugs (Figure 4-24) are placed on the sprinklers. The caps blow off the sprinklers at approximately 20 psi, after the deluge valve opens and allows the high pressure water to enter the system.

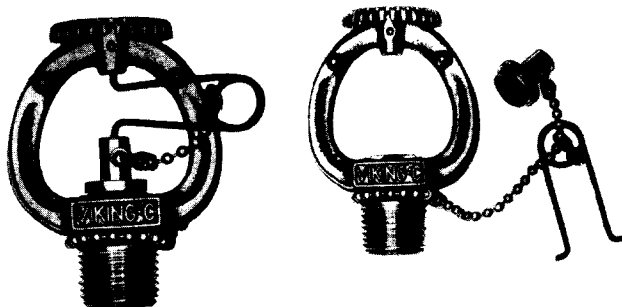


FIGURE 4-24
SPRINKLER PRE-PRIME PLUGS

4.1.2.5 Pre-Action Systems. A pre-action system differs from a deluge sprinkler system only in that it has normally closed automatic sprinklers. When the fire detecting device is actuated, the water control valve opens and admits water to the piping system. The system then acts the same as a wet pipe system; individual sprinklers are operated by heat. The advantage of the pre-action system is that the probability of inadvertent water discharge is minimized since both operation of the detection system and automatic sprinklers is necessary to effect discharge.

Occasionally, pre-action systems are incorrectly referred to as dry pipe sprinkler systems. While it is true that the pre-action system piping does not contain water, the term dry pipe system refers to the type of sprinkler system and the type of water control valve which operates this sprinkler system. Actually a pre-action system uses a deluge valve or a modified dry pipe valve for operation of the sprinkler system. Since automatic sprinklers are used on the piping network, the term "pre-action system" was coined to describe this type of sprinkler system. There are two types of pre-action sprinkler system: supervised and unsupervised.

A supervised pre-action system has air introduced into the system piping at a pressure of approximately 5 psi. This slight air pressure on the system piping "supervises" the piping to detect leaks. The pressure switches used for detection of low air pressure on the "supervised" system should record in "inches of water" rather than "pounds per square inch." An unsupervised pre-action system is not monitored continuously.

4.1.2.6 Combined System. A combined system (Figure 4-25) is a special purpose arrangement using two modified dry pipe valves connected to tripping devices and piped in parallel to supply water to the same sprinkler system. The piping network is filled with air under pressure. When a fire is detected, an exhaustor at the end of the system opens and releases the air within the system. The system then operates the same as a preaction system. However, if the detection system fails, the combined system acts the same as a dry pipe system and allows water to be admitted to the system when sprinklers open and discharge the air in the piping network.

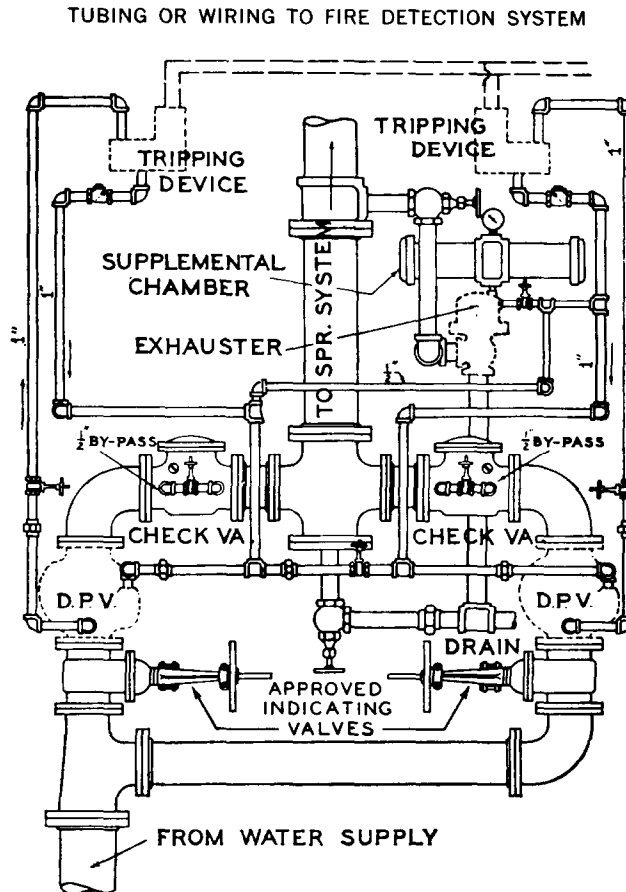
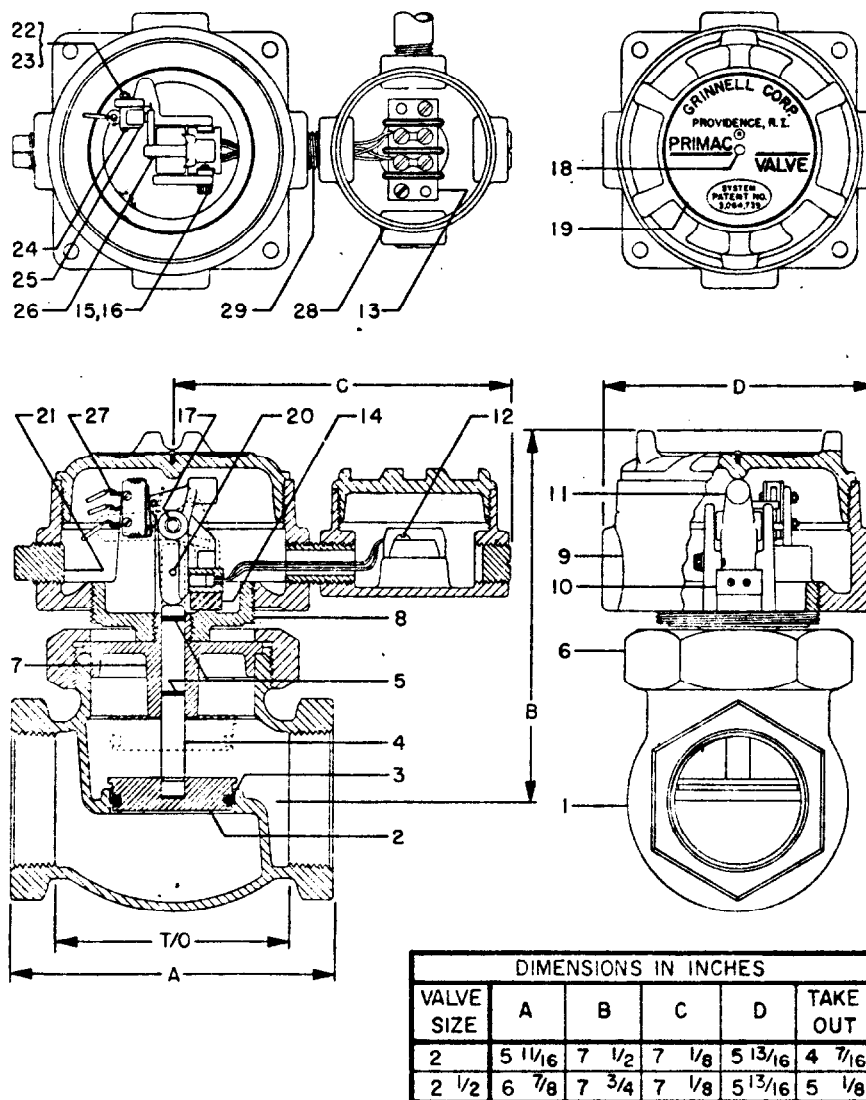


FIGURE 4-25
COMBINED SYSTEM HEADER ARRANGEMENT

4.1.2.7 Rapid Reaction Water Suppression Systems. In some cases, it may be necessary to get water to an area in less than one second (for example, areas where rocket and ammunition propellants are stored and handled). Basically there are two types of rapid reaction water suppression systems: (1) an explosive operated deluge valve, or (2) a pilot operated nozzle system.

- Explosive Operated Deluge Valve. The explosive operated deluge valve (Figure 4-26) links the clapper latch in the deluge valve directly to an explosive device, called a squib. When a fire is detected, the squib fires and unlatches the clapper, allowing the instantaneous flow of water. These systems usually use the "pre-priming" technique so that water is discharged from the nozzles almost as soon as the explosive squib is fired.



LEGEND

- | | | | |
|-----|-------------------------------------|-----|----------------------------|
| 1. | BODY | 18. | DRIVE SCREW |
| 2. | PLUG | 19. | IDENTIFICATION DISC |
| 3. | O-RING | 20. | LATCH SHEAR PIN |
| 4. | SHAFT | 21. | PLUG, 1/2" |
| 5. | O-RING | 22. | HEX NUT |
| 6. | BONNET NUT | 23. | SPRING LOCK WASHER |
| 7. | BONNET | 24. | ROUND HEAD MACHINE SCREW |
| 8. | BONNET TOP | 25. | SWITCH, SINGLE POLE DOUBLE |
| 9. | JUNCTION CONDULET WITH COVER | | THROW CONTACTS, 15.0 AMPS. |
| 10. | PRIMER HOLDER | | NON-INDUCTIVE LOAD, 1/2 |
| 11. | LATCH | | H.P. 125/250 V. A.C. |
| 12. | ROUND HEAD MACHINE SCREW | 26. | RADIAL LOCKING PIN |
| 13. | TERMINAL BLOCK | 27. | ELECTRICAL LEADS, 18 GAUGE |
| 14. | BUMPER | | 60 C, 600 V. |
| 15. | SPRING LOCK WASHER, FOR NO. 8 SCREW | 28. | JUNCTION BOX, WITH COVER |
| 16. | SOCKET HEAD CAP SCREW | | AND 3 PLUGS |
| 17. | RADIAL LOCKING PIN | 29 | NIPPLE, 1/2" X CLOSE |

FIGURE 4-26
EXPLOSIVE OPERATED DELUGE VALVE (GRINNELL PRIMAC MODEL B-2)

- **Pilot Operated Nozzle System.** In the pilot operated nozzle system (Figure 4-27), the nozzles are attached to a piping network constantly filled with pressurized water. The nozzles are kept closed by a poppet obstructing the waterway between the piping network and the nozzle orifice. Upon fire detection, the pressure in the pilot line is released by the actuation of a solenoid valve. The water pressure in the piping network pushes the poppet back and allows the water to immediately flow through the nozzle.

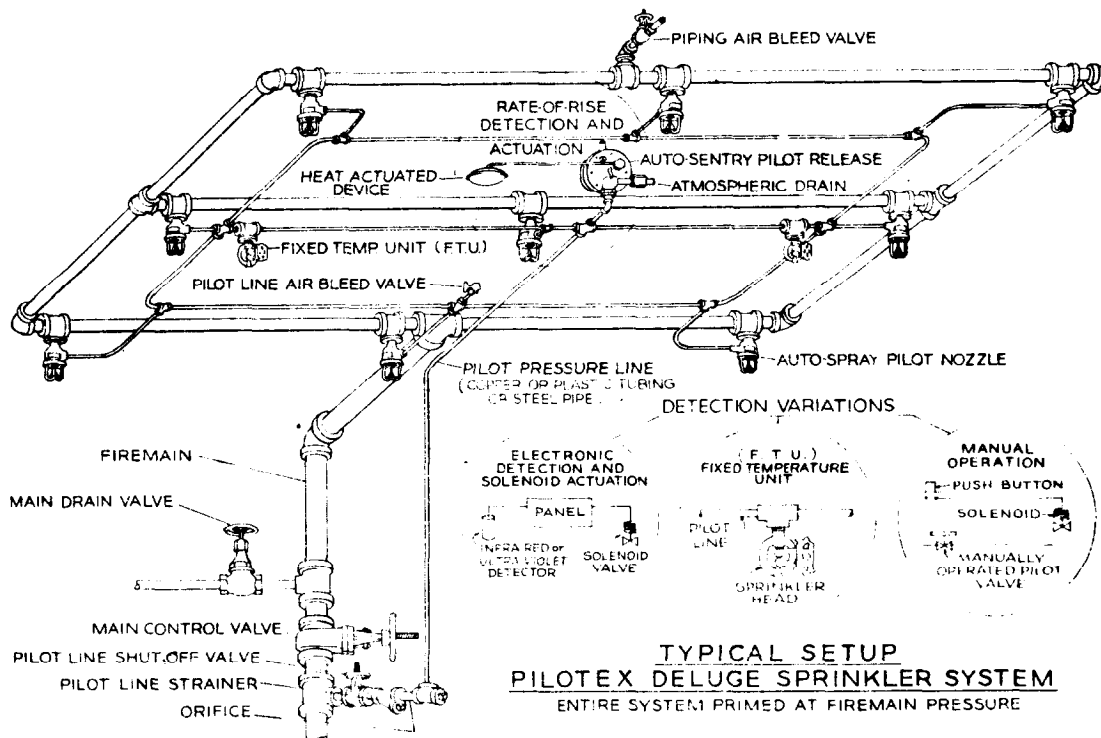


FIGURE 4-27
PILOT OPERATED NOZZLE SYSTEM (AUTOMATIC SPRINKLER PIPOTEX)

4.1.2.8 Residential Sprinkler Systems. Residential Sprinkler systems are designed and installed in accordance with the National Fire Protection Association's Standard for the Installation of Sprinkler Systems in One-and Two-Family Dwellings and Mobile Homes (NFPA 13D). Unlike other sprinkler systems, the design objective of residential sprinkler systems is to extinguish a fire with a minimal supply of water. In order to accomplish this objective, the standard sprinkler head had to be modified to respond more quickly (while the fire was still small) and distribute water around the edges of a room. Another hardware change brought on by a desire to reduce the cost of a system, was the use of plastic pipe, described in section 4.1.3.

4.1.3 Piping Materials. The two most common piping materials used in sprinkler systems are steel and copper. Either schedule 10 (thin-wall) or schedule 40 steel pipe is used. Copper pipe should be joined with a low-lead content solder, where permitted, especially if the sprinkler system is connected to the domestic water supply.

In recent years, plastic pipe has been developed for sprinkler system applications. Both polybutylene (PB) and post-chlorinated polyvinylchloride (CPVC) pipe have been listed for use in sprinkler systems. Currently, plastic pipe is only accepted for wet pipe systems. PB pipe is joined by heat-fusion tool and is relatively flexible. CPVC pipe is glued together and is fairly rigid. It is important that plastic pipe be supported at regular intervals, just like metallic pipe. Only hangers explicitly for plastic pipe should be used. Special schedules are available for hanger spacing for the CPVC and PB pipe.

4.1.4 Local Alarms for Sprinkler Systems. Sprinkler systems which are installed in accordance with the National Fire Protection Association's Standard for the Installation of Sprinkler Systems (NFPA No. 13) have a local alarm at the riser. They may also have alarms connected to a building or base alarm system as described in Chapters 2 and 3. There are two types of local alarms, water motor alarms and electric alarm bell.

- **Water Motor Alarm.** A water motor alarm (Figure 4-28) is a hydromechanical alarm made of a water-powered motor, a striker, and a gong cover. When water flows in the sprinkler system, part of the water is diverted from the alarm valve or dry pipe valve through the water motor which causes the striker to clang the gong. The alarm continues to sound as long as water is flowing through the sprinkler system. The alarm may be shut off by closing the alarm control valve located in the piping between the alarm or dry pipe valve and the water motor alarm.
- **Electric Alarm Bell.** An electric alarm bell is actuated by a circuit closer in the form of a waterflow vane switch or a waterflow pressure switch. For more discussion on the actuator, see Chapters 2 and 3.

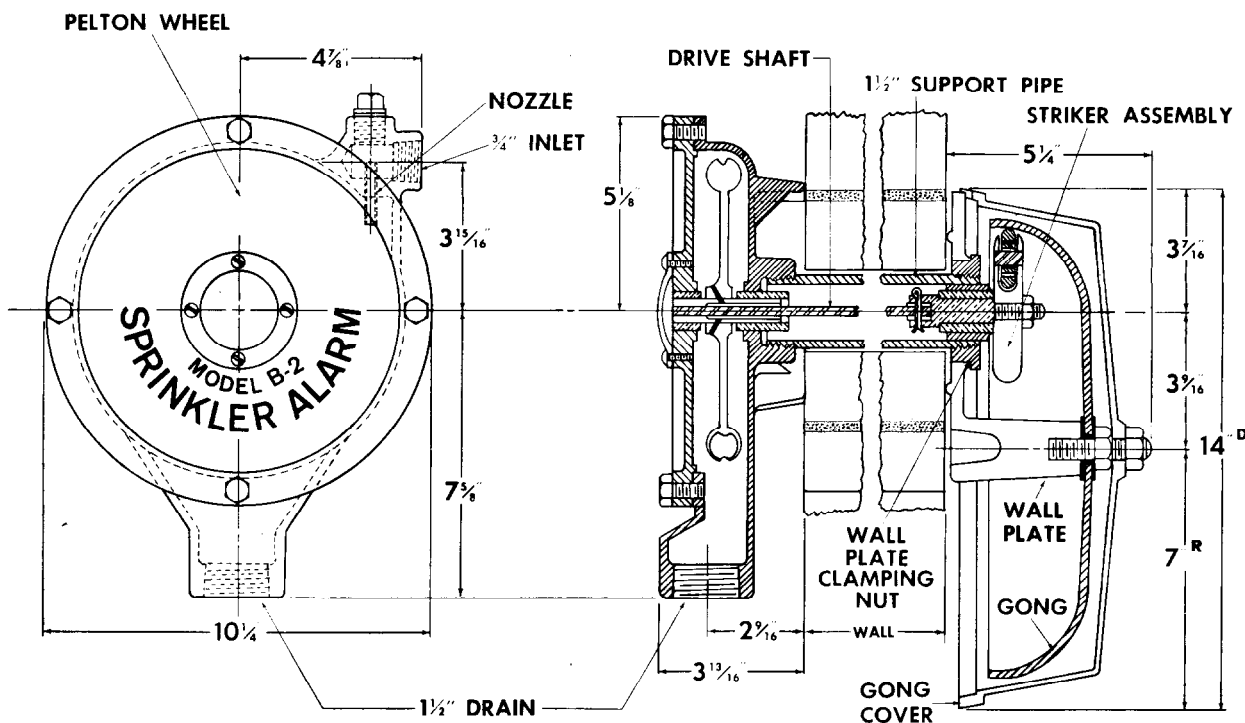


FIGURE 4-28
WATER MOTOR ALARM

4.2 STANDPIPE SYSTEMS. Standpipe systems provide water for fire hose use.

4.2.1 Classification of Standpipe Systems. Standpipe systems are classified by type of use according to NFPA Standard 14, "Standpipe and Hose Systems."

- Class I Systems (2-1/2-inch hose connections) are for use by fire department personnel and others who are trained in handling heavy fire streams.
- Class II Systems (1-1/2-inch hose connections) are primarily intended for use by the building occupants.
- Class III Systems have both large (2-1/2-inch) outlets and small (1-1/2-inch) outlets and are for use by both fire department personnel and building occupants. This multiple use system can have both a large hose connection and a small hose connection or a large (2-1/2-inch) hose connection with an easily removable 2-1/2 by 1-1/2-inch adapter attached to the large hose connection.

4.2.2 Types of Standpipe Systems. Standpipe systems may be wet, dry, or combined. Wet standpipe systems are continuously supplied with water at every hose valve. Dry standpipe systems normally do not contain water. Typical arrangements of dry standpipe systems include:

- A system controlled by a normally closed valve which must be opened manually.
- A system controlled by a dry pipe or deluge valve. This system has a delay in obtaining water because of the time required to expel the air from the system before the dry pipe valve will trip. Also, if hose is attached to the hose outlet kinks in the hose can increase the time delay. A deluge valve reduces the time delay but requires some method of remote control actuation.
- A system with standpipes not connected to a water supply at all. A fire department connection (siamese connection) at the base of the standpipe is "charged" by connecting large (2-1\2-inch) hose from a fire hydrant or fire truck, supplying the standpipe system.
- Combined sprinkler and standpipe systems are those in which the piping serves both sprinklers and hose outlets.

4.3 WATER SUPPLIES FOR SPRINKLER AND STANDPIPE SYSTEMS. Water supplies which serve sprinkler and standpipe systems must be adequate and reliable. To determine the amount of water necessary for sprinkler and standpipe systems, the rate of flow and pressure needed for the effective performance must be known. If it is likely that additional fire hose streams from outside the building will be required, these should also be included. The combination of water needed for sprinkler and standpipe systems and for outside hoses is the fire flow demand.

An adequate system is one which can deliver the required fire flow for a specified time with domestic water consumption at the maximum rate. To be reliable, the system must also be able to deliver the fire flow demand under

certain emergency conditions, such as a supply main or pump being out of service. The desired reliability of the system will depend upon the nature of the protected structure (people, property or mission).

Distribution systems transmit the water from its supply to point of use. The distribution systems consist of pipes and other accessories for the control of the water within the pipes. Water may be supplied by public or base sources, water tanks, or fire pumps.

4.3.1 Public (or Base) Water Supplies. The most common type of water supply is from the public (or base) water distribution system. These systems supply domestic water in addition to water for fire protection purposes.

4.3.1.1 Fire Hydrants. The most common component for fire protection purposes is the fire hydrant. There are two types of fire hydrants in general use today.

- Dry barrel, or base valve, hydrants (Figure 4-29) are the most common. These hydrants have the control-valve below the frost line and between the foot piece and the barrel of the hydrant. Such hydrants are also known as a "frost proof" hydrant.
- Wet barrel hydrants (Figure 4-30) are sometimes used when there is no danger of freezing weather. Wet barrel hydrants usually have a compression-type valve at each outlet to control the flow of water. Some other types have one control valve in the bonnet which controls the water to all of the outlets.

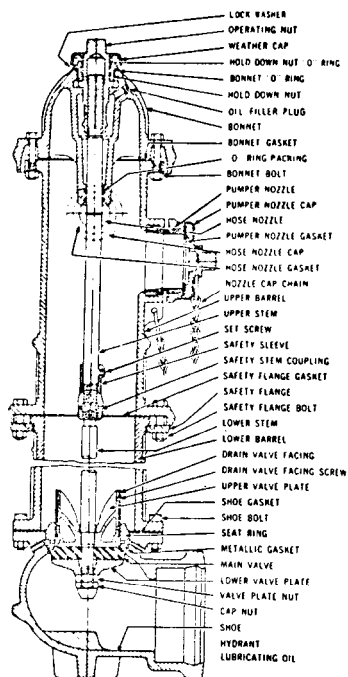


FIGURE 4-29
DRY BARREL FIRE HYDRANT

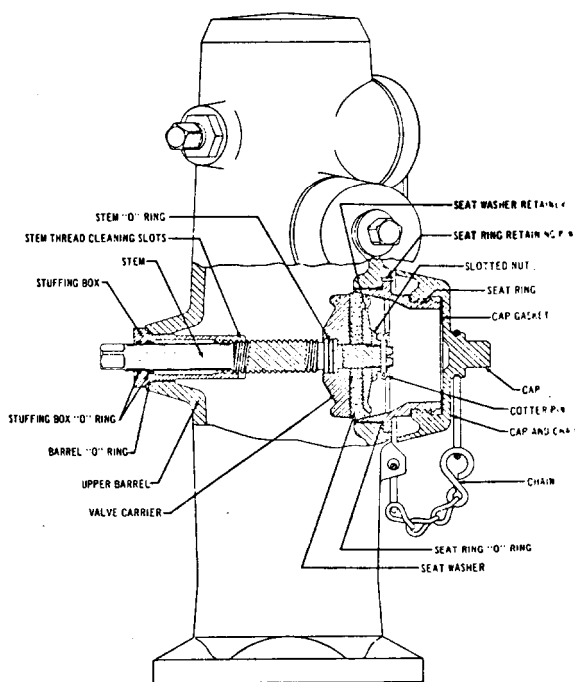


FIGURE 4-30
WET BARREL FIRE HYDRANT

4.3.1.2 Fire Department Connections. Sprinkler and standpipe systems supplied by public (or base) water systems are equipped with fire department connections (Figure 4-31) which allow the fire department to increase the

pressure in the sprinkler or standpipe system. This is done by connecting the suction line of a pumper fire truck to a fire hydrant and connecting two or more 2-1/2-inch diameter discharge lines from the pumper truck to the fire department connection.

4.3.2 Water Tanks.

Preferably, water tanks used for sprinkler and standpipe systems are not used for other purposes. The frequent filling of a tank which is necessary when water is used for other purposes produces numerous effects to increase maintenance requirements. For example, sediment may accumulate in the bottom of the tank. When water is drawn from the bottom of the tank, the sediment may also be drawn into the sprinkler and standpipe systems and cause obstructions to the fire protection equipment.

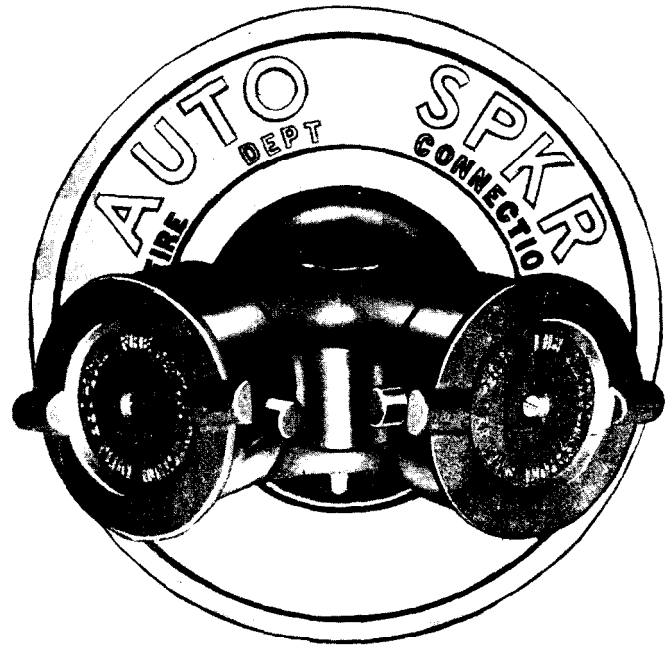
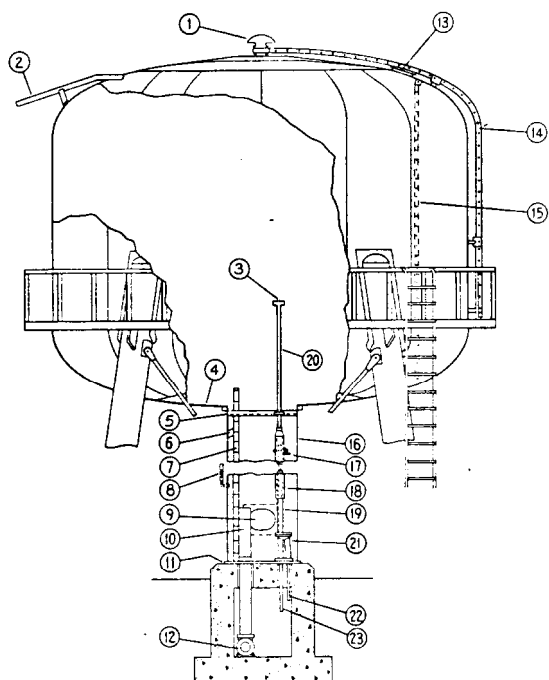


FIGURE 4-31
FIRE DEPARTMENT CONNECTION

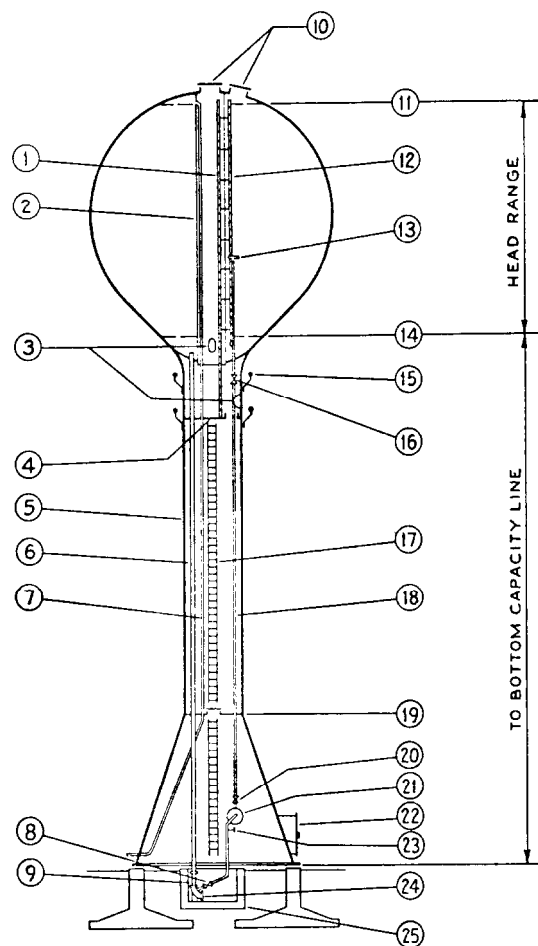
4.3.2.1 Types of Water Tanks. There are three main types of water tanks.

- Gravity Tanks. Gravity tanks (Figure 4-32) are usually made of wood or steel and are elevated. In some cases, gravity tanks are installed directly on a building roof. Gravity tanks provide dependable pressurization of fire protection systems since the pressure is provided by the elevation difference between the tank height and the height of the fire protection system.
- Suction Tanks. Suction tanks (Figure 4-33) are usually steel although occasionally they are made of concrete or a rubberized fabric. Rubberized fabric tanks are supported by a specially prepared excavation, earthen berm, or both. Suction tanks are used to store water to provide a reliable source of water for fire pumps,
- Pressure Tanks. Pressure tanks (Figure 4-34) are used to supply water for limited fire protection purposes. They are made of steel and are normally kept one-half or two-thirds full of water. Air pressure inside the tank is supplied by an air compressor. The air pressure in the tank forces water out to the sprinkler system in the event of fire.



1. Perforated plate or screened finial vent
2. Stub overflow pipe
3. Hot-water tee outlet at one-third depth
4. Tank bottom
5. Heater-pipe brace
6. Ladder bracket
7. Ladder in riser
8. Thermometer
9. Manhole
10. Inlet and discharge pipe
11. Grout under riser base plate
12. C. I. base elbow
13. Roof hatch with hinged cover and catch to keep

Fixed-type outside ladder
 Inside ladder
 Steel riser
 Pipe support
 Hot-water circulating pipe
 W. I. condensing pipe
 Hot-water pipe
 Heater connection
 Condensate outlet
 Steam inlet



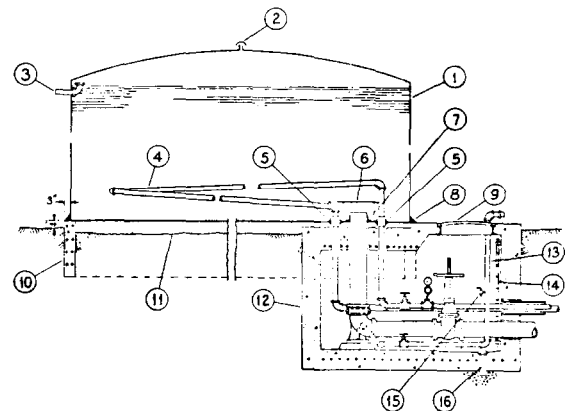
1. Roof access ladder
2. Access tube
3. Manholes
4. Platform
5. Supporting pedestal
6. Insulated riser pipe
7. Overflow pipe
8. Gate valve (OS&Y)
9. Expansion joint
10. Roof manholes with rainproof doors
11. High-water line
12. Tank-access ladder
13. Hot-water tee outlet at one-third depth
14. Low-water line
15. Painters ring
16. Gate valve (OS&Y)
17. Ladder
18. Insulated heater pipe
19. Condensate ceiling
20. Gate valve (OS&Y)
21. Heat exchanger
22. Door (optional)
23. Thermometer
24. Base elbow
25. Valve pit

FIGURE 4-32
 GRAVITY TANKS

4.3.2.2 Methods of Heating.

Adequate heating is needed in tanks to prevent the water from freezing. The importance of heating ranks second only to structural design of the tank. The water in the tanks should be maintained at 42 to 50°F. Heating water higher than 50°F requires too much fuel. Also, water heated to 100°F can damage wooden tanks and the paint on some steel tanks. Water has its maximum density at 39.2°F. When the water falls below 39.2°F, a water inversion causes the warmer water to settle to the bottom of the tank and the colder water to rise. There are several methods of heating water.

- Gravity Circulation. Gravity (Figure 4-35) draws cold water from the tank discharge pipe or low point of a suction tank. The withdrawn water is passed through a heater. The heated water then naturally rises through a separate hot water pipe into the tank. To be effective, gravity circulation heating equipment must be located at or near the base of the tank being heated.



1. Approved pump suction tank
2. Screened vent
3. Stub overflow pipe
4. Steam coil for heating
5. Extra-heavy couplings welded to tank bottom
6. Vortex plate
7. Watertight lead slip joint
8. Flashing around tank
9. Round manhole with cover
10. Concrete ring wall
11. Sand or concrete pad (depending upon soil conditions)
12. Valve pit
13. Drain pipe
14. Ladder
15. Drain cock, 1/2 in.
16. Valve-pit drain

FIGURE 4-33
SUCTION TANK

An accurate thermometer or temperature recording device must be located on the cold water pipe and the temperature monitored closely to prevent freezing the water. Electrical temperature supervision of the tank may also be provided.

- Forced Circulation. Forced circulation heating systems use an electric motor driven pump to circulate the heated water. Heating equipment can be remote from the tank (Figure 4-36). A reliable electric supply is required for the circulation pump.
- Vertical Radiator. Vertical radiator heaters (Figure 4-37) are used for heating water in elevated tanks with large steel plate risers. The radiator element is inside a sleeve. Cold water enters the bottom of the sleeve, is heated by the radiator, rises, and discharges into the tank.
- Direct Discharge of Steam. Direct discharge of steam uses a steam line which enters the tank through the bottom and extends above the water level of the tank, turns, and then discharges steam directly into the water three to four feet below the normal fire service level. A check valve and air vent at the top of the steam line prevent water in the tank from siphoning back down the steam line.

- Steam Coil Inside Tanks. Steam coils are not suitable for elevated tanks because of the inconvenience of observing the water temperature. Steam coils can be used on suction tanks with flat bottoms (Figure 4-33). The steam coil must be submerged continuously and substantially supported at least 1 foot above the bottom of the tank. The coil must be installed in the tank so it is pitched to drain and it must have steam pressure of at least 10 psi.

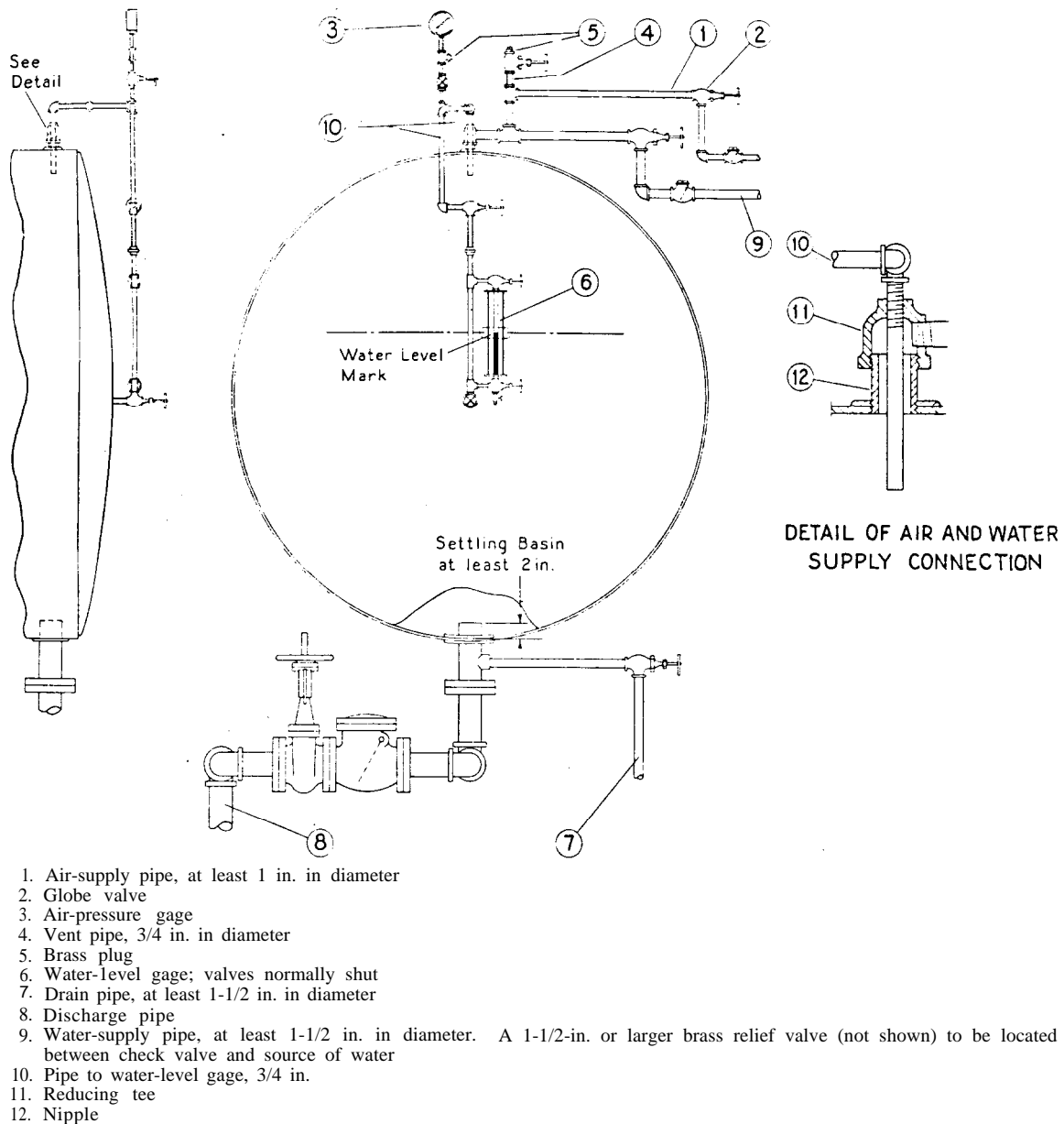
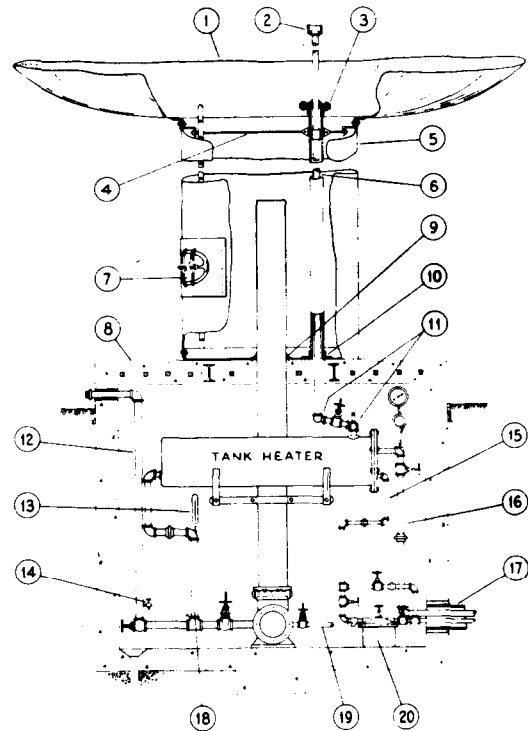


FIGURE 4-34
PRESSURE TANK



1. Steel gravity tank
2. Hot-water outlet
3. Outer pipe
4. Brace rods, at least 1/2 in. in diameter and not more than 25 ft apart
5. Large steel-plate riser
6. Hot-water circulating pipe
7. Mannhole cover
8. Hollow-center pier
9. Welded connection
10. Watertight joint
11. Four-elbow joint
12. Drain pipe
13. Thermometer
14. Drain cock, 1/2 in.
15. Condensate return
16. Steam-supply pipe
17. Conduit for steam pipes and connection from mercury gage
18. Cold-water circulating pipe
19. Pipe from mercury gage
20. Steam trap

FIGURE 4-35
GRAVITY CIRCULATION TANK HEATING SYSTEM

- Direct-Fired Heaters. Steel suction tanks can be heated by oil or gas fired heaters, discharging directly into an open pipe which extends into the tank near the bottom. The heated water surrounding the pipe continuously rises to the surface, heating the colder water. A thermostat must be near the bottom of the tank, away from the heating pipe, to insure adequate heating of all the water.

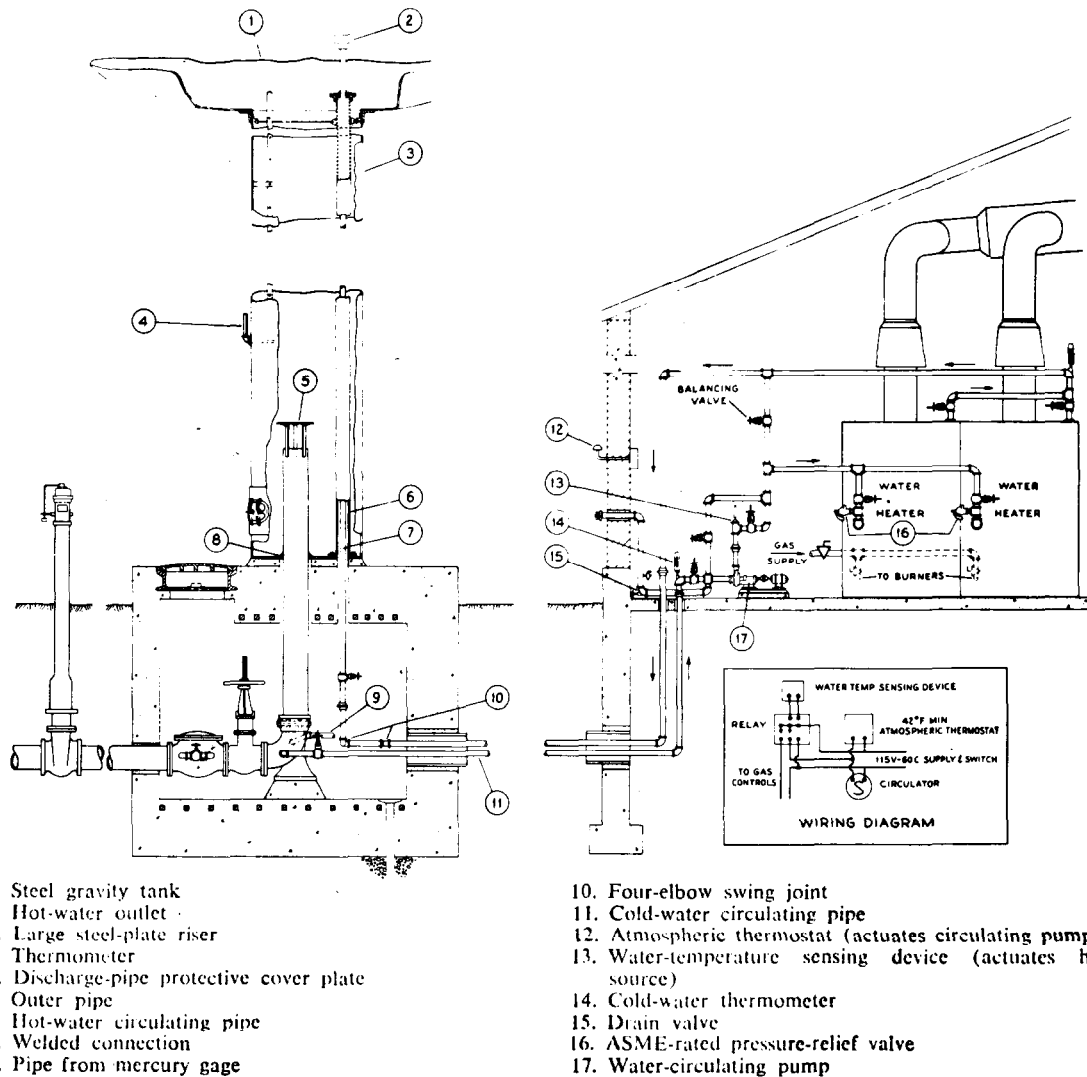


FIGURE 4-36
 FORCED CIRCULATION TANK HEATING SYSTEM

4.3.2.3 Corrosion Protection. Corrosion is caused by the flow of ionic currents from numerous anodic areas through the electrolyte to cathodic areas on the tank shell. Corrosion is seen as rust and pits which form on steel surfaces. All interior surfaces of steel tanks are subject to corrosion. To impede corrosion, the interior surfaces are painted. The degree of corrosion depends on the quality of the paint coating, the characteristics of the water, and environmental factors. An economical and effective alternate to frequent interior repainting is cathodic protection. Cathodic protection counteracts corrosion by passing sufficient direct current from an outside power source, through anodes suspended in the water, to the tank shell.

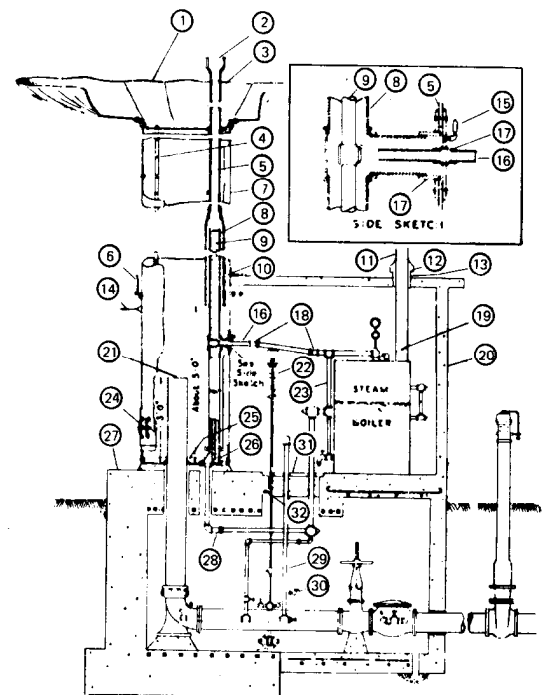
4.3.3 Fire Pumps. Often the flow and pressure requirements of sprinkler and standpipe systems exceed the capabilities of the public or base water supply system. In these instances, fire pumps are commonly used to satisfy these higher pressure requirements. Generally two types of fire pumps are used to supply sprinkler and standpipe systems. They are either the horizontal shaft centrifugal type or the vertical shaft turbine type.

- The centrifugal type pump (Figure 4-38) is used where the suction source is available under pressure to the fire pump unit; for instance, from the public or base water mains or from a grade level tank.
- The vertical turbine pump is used where the supply source is below the pumping unit; for instance, from a pond or underground reservoir (Figure 4-39).

Fire pumps are required to meet a characteristic curve to be "listed" or "approved" for fire protection service. The pump must be able to deliver rated flow at rated pressure when operating at rated speed. The unit must also be able to deliver 150% of rated flow at 65% of rated pressure and produce a maximum pressure at shut-off (no flow) at 120% of rated pressure for centrifugal pumps and 140% of rated pressure for vertical turbine pumps (Figure 4-40). Fire pumps may be single stage or multiple stage. Multiple stage pumps are for high pressure demands.

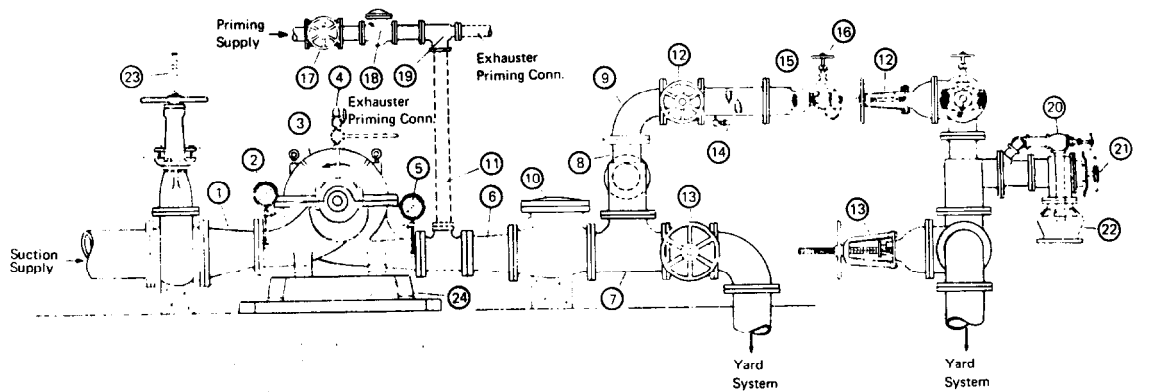
A fire pump unit is an assembled unit consisting of a fire pump, its driver, a controller (motor starter), and accessories. The typical accessories are described below.

- Circulation Relief Valve. When pumps are operating against a closed head, the water in the pump casing heats up and could physically damage the fire pump. To prevent the water from overheating, a 3/4-inch circulation relief valve is provided to allow enough water to be wasted and replenished to prevent overheating.



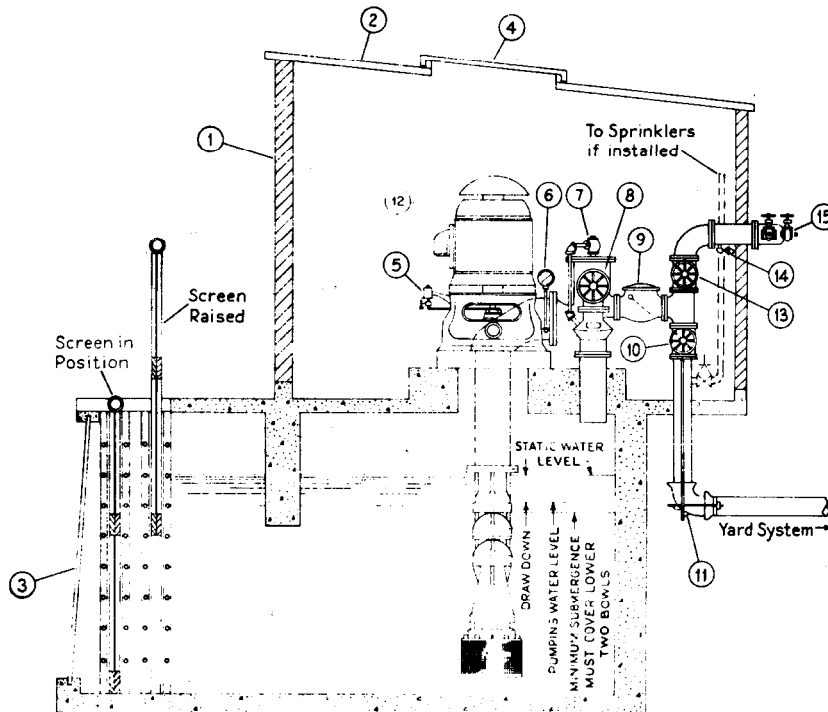
1. Steel gravity tank
2. Hot-water outlet
3. Extension above sleeve
4. Brace rods, at least $\frac{1}{2}$ in. in diameter, not more than 25 ft apart
5. Large steel-plate riser
6. Thermometer
7. Sleeve around radiator element
8. Condensing chamber closed at top
9. Steam pipe open at top
10. Flashed joint
11. Vent or stack
12. Apron
13. Thimble
14. Temperature-sensing element for automatic control of boiler when desired. Locate at least 1 ft away from heater
15. Air vent
16. Steam-supply pipe
17. Extra-heavy coupling welded to plate
18. Four-elbow swing joint
19. Damper if needed
20. Noncombustible heater house
21. Discharge pipe
22. Mercury gage
23. Hartford pipe loop
24. Manhole cover
25. Welded connection
26. Drain holes, $\frac{1}{4}$ in. in diameter
27. Hollow-center pier and valve pit
28. Condensate return
29. Drain pipe
30. Drain cock, $\frac{1}{2}$ in.
31. Iron grating
32. Calking where pipes pass through sleeves in concrete floor

FIGURE 4-37
VERTICAL RADIATOR TANK
HEATING SYSTEM



- | | | |
|---|----------------------------------|-----------------------------------|
| 1. Eccentric reducer | 7. Discharge tee | 16. Hose valves and caps |
| 2. Suction gage | 8. Reducing tee | 17. Priming-connection OS&Y valve |
| 3. Pump | 9. Reducing elbow or tee | 18. Priming check valve |
| 4. Umbrella cock- or air-release valve | 10. Discharge check valve | 19. Reducing tee |
| 5. Discharge gage (for automatic operation) | 11. Connection to priming supply | 20. Test valve |
| 6. Increaser | 12. Hose-connection OS&Y valve | 21. Pressure-relief valve |
| | 13. Discharge OS&Y valve | 22. Waste cone |
| | 14. Ball drip | 23. Suction OS&Y valve |
| | 15. Detachable hose header | 24. Bedplate |

FIGURE 4-38
HORIZONTAL SHAFT CENTRIFUGAL FIRE PUMP INSTALLATION



1. Suggested size of pump room for one pump 12 by 16 by 10 ft high. Larger rooms for multiple-pump installations. Walls of noncombustible construction: brick, tile, concrete, or corrugated asbestos on steel frame (last suitable only where climate makes heating unnecessary). Floor of concrete
2. Noncombustible roof; otherwise install sprinklers
3. Trash rack, 1/2-in. flat or 3/4-in. round steel bars spaced 2 to 3 in. apart
4. Roof hatch
5. Solenoid oil valve; oils line-shaft bearings
6. Discharge gage
7. Automatic air release
8. Pressure-relief valve, waste cone, and waste pipe
9. Discharge check valve
10. Discharge OS&Y valve
11. Discharge pipe
12. When gasoline engine is driver, fuel tank outside pump room in sand-filled masonry or concrete enclosure
13. Hose-connection OS&Y valve
14. Ball drip
15. Detachable hose header and hose valves

FIGURE 4-39
VERTICAL SHAFT TURBINE FIRE PUMP INSTALLATION

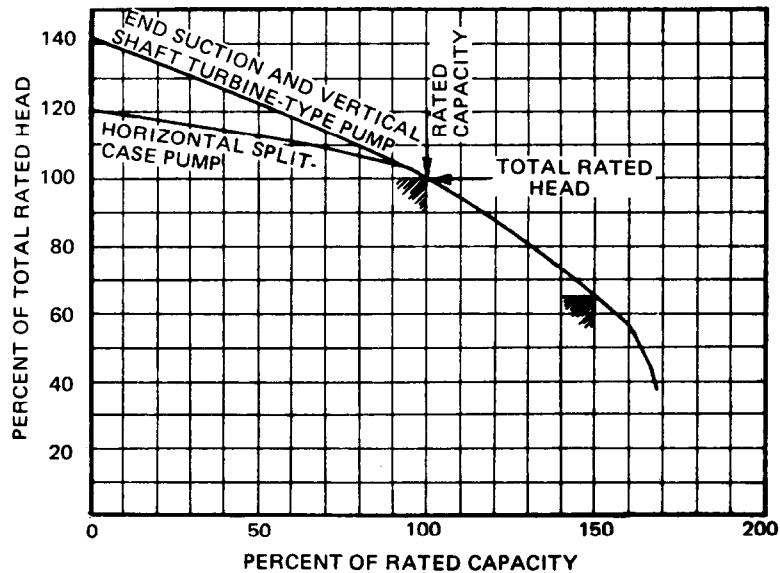


FIGURE 4-40
CHARACTERISTIC CURVES OF HORIZONTAL
VERTICAL SHAFT FIRE PUMPS

- Pressure Relief Valve. Fire pumps powered by variable speed drivers or where the discharge pressure may exceed the working pressure of the pipe fittings in the system are equipped with a pressure relief valve (Figure 4-38). This valve allows pressure to be bled off the system when it reaches the "set" point of the valve. Typically this set point is adjusted to a pressure slightly below maximum achievable pressure of the pump or below the working pressure of the pipe fittings. This allows the relief valve to operate each time the pump is started and prevent it from sticking closed.
- Testing Devices. Pumps are arranged for testing to determine, periodically, that the pump is capable of producing rated quantity at rated pressure.

Two different types of testing devices are available for use on pumps.

- Hose Header. The hose header (Figure 4-38) is a cast iron head which has between two and eight 2-1/2-inch hose valves attached to it, with one 2-1/2-inch hose valve for each 250 gpm of pump capacity. Lengths of 2-1/2-inch fire hose are attached to the valves; nozzles (called playpipes) are placed on the hoses. The playpipe has a standard bore of 1-3/4-inches and a removable tip with a bore of 1-1/8-inches.

Testing with this type of arrangement is usually accomplished by placing a pitot tube (Figure 4-41) with gauge into the flowing stream of water and recording the pressure. This pressure is the velocity pressure of the water, which is convertible to gallons per minute by charts or the formula:

$$Q = 29.83 C d^2 \sqrt{p}$$

where: Q = water flow rate in gpm.
 C = coefficient of discharge of the nozzle
 d = orifice diameter in inches
 p = pressure recorded on the pitot gauge in psi

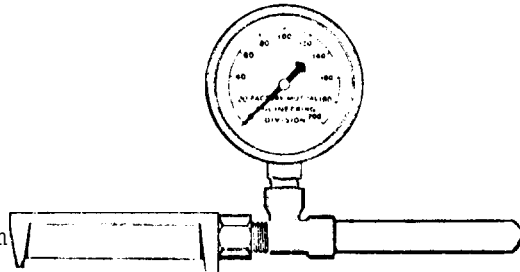


FIGURE 4-41
PITOT TUBE

- Flow Meters. Flow meters (Figure 4-42) directly measure the flow of water from the pump in gallons per minute. The inlet to these devices is connected to the pump discharge piping and provided with a calibrated meter. The meters may be orifice plate or venturidesign. In both cases, the differential pressure across the restriction is measured and then converted to gallons per minute. The meters are calibrated at the factory and no field adjustments are needed.

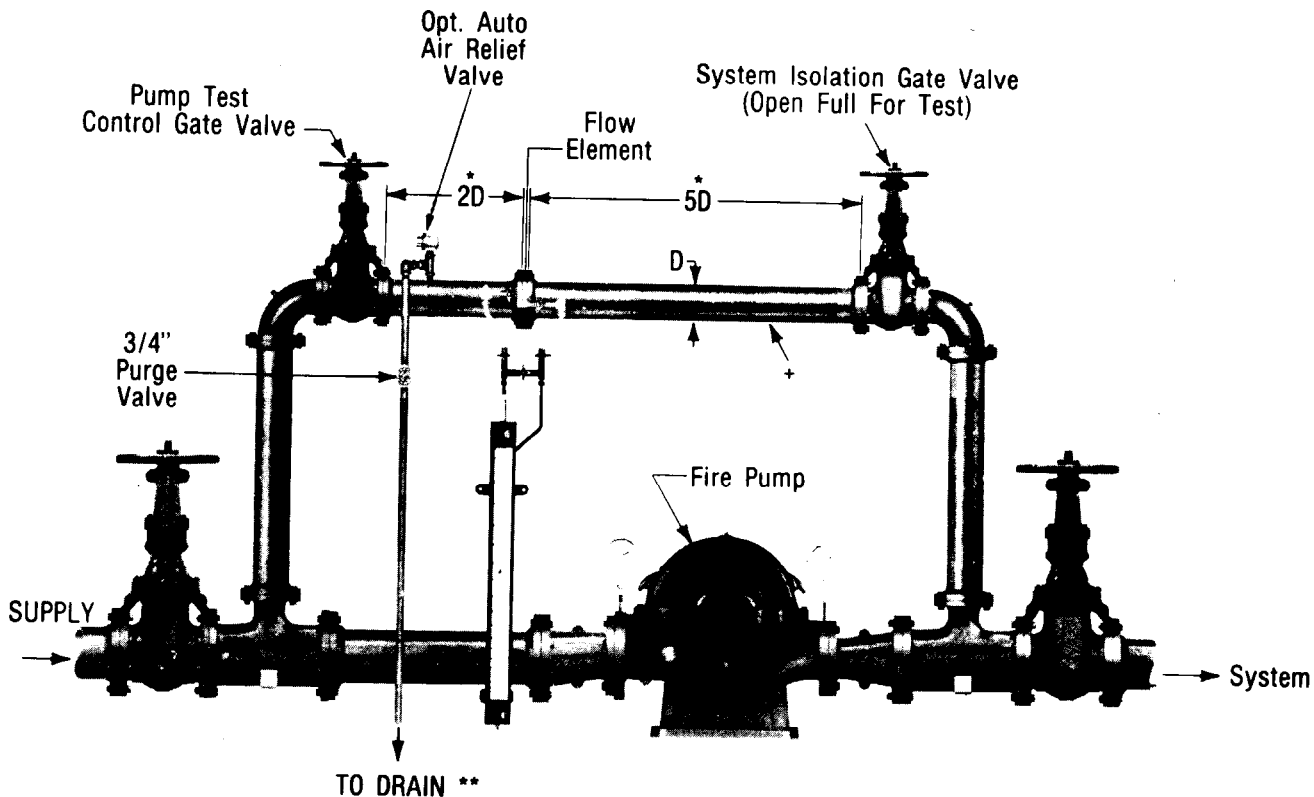


FIGURE 4-42
FLOW METER INSTALLATION

4.3.3.1 Horizontal Split-Case Centrifugal Pump. Horizontal split-case centrifugal pumps (Figure 4-43) are the most common type. They are characterized by easy accessibility to all working parts, rugged construction, liberal water passages, ample strength in all working parts, and having corrosion-resistant material for working parts exposed to corrosion. In these pumps, waterflow from the suction inlet in the casing divides and enters the center of the impeller from each side through an opening called the "eye." Rotation of the impeller drives the water by centrifugal force from the eye to the rim, and through the casing volute to the discharge outlet. When centrifugal pumps are arranged for automatic or remote control, they are usually provided with an automatic air release which prevents air from becoming entrained in the water and causing damage to the pump.

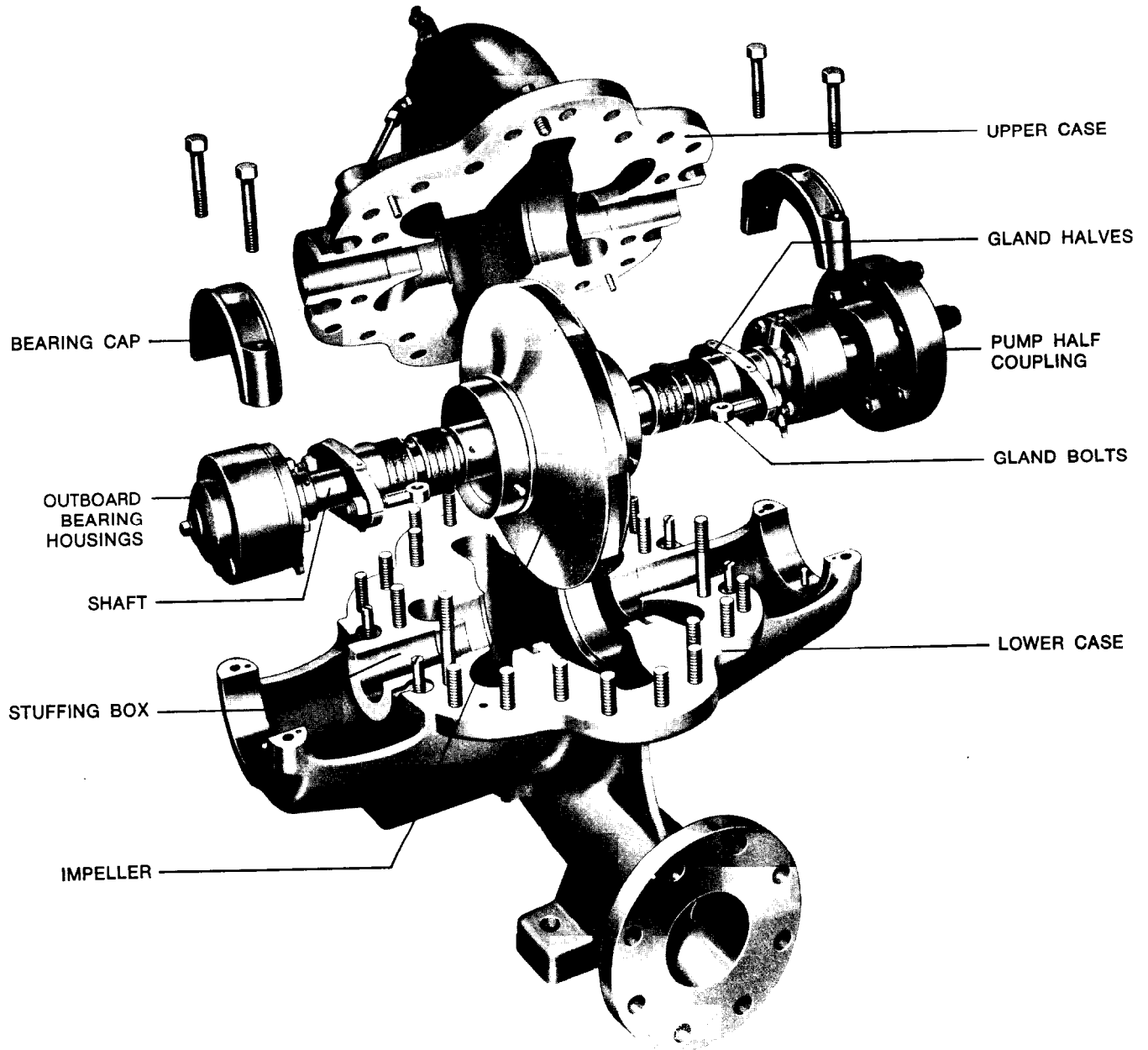


FIGURE 4-43
HORIZONTAL SPLIT-CASE CENTRIFUGAL FIRE PUMP

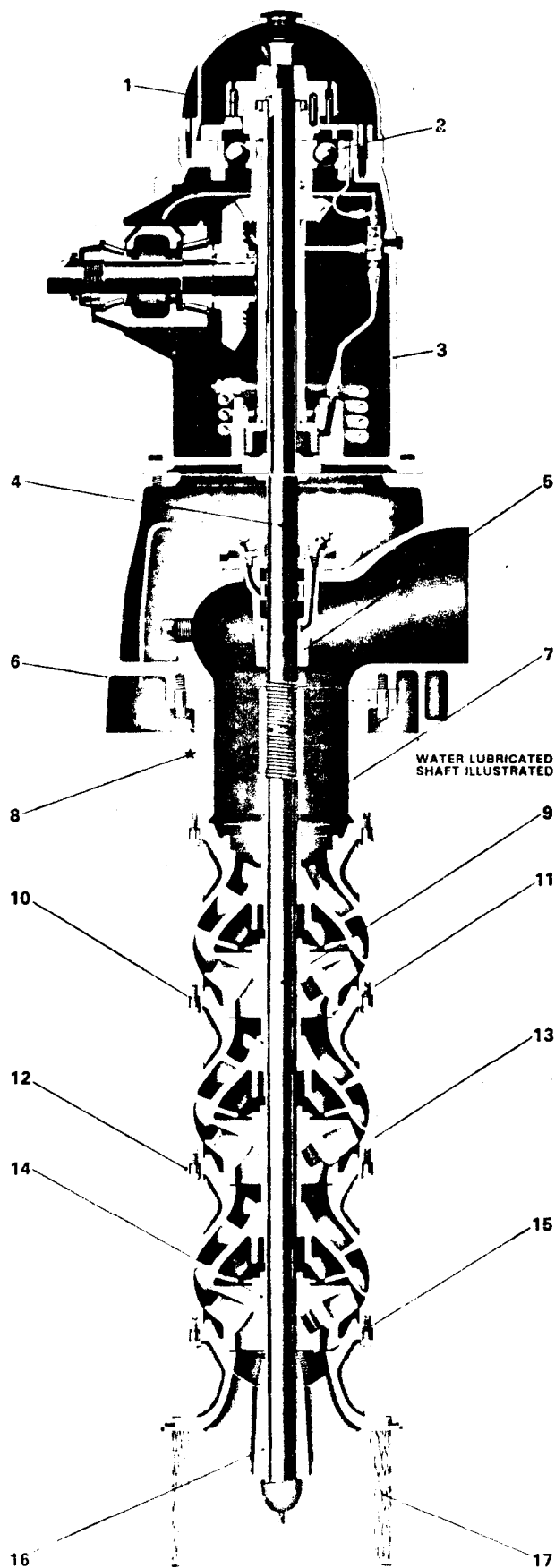
4.3.3.2 Vertical Shaft Turbine Pump. A vertical shaft fire pump (Figure 4-44) consists of a motor head or right-angle gear drive, a column pipe and discharge fitting, an automatic air release, a drive shaft which may be open or enclosed, a bowl assembly (where the impellers are located), and a suction strainer. The vertical turbine pumps have their impellers suspended from the pump head by a vertical shaft within a column pipe, which also serves as a support for the line bearings. The column pipe containing the pump shaft and impellers is submerged in the suction water supply. The water pressure is elevated from one impeller to another and finally discharged from the pump outlet. Typically, a vertical turbine pump is powered by an electric motor mounted on top of the pump with the shaft of the motor vertically aligned. When using an internal combustion engine or a steam turbine driver, a right-angle gear drive is used to transmit power from the engine to the pump.

4.3.3.3 Drivers and Controllers. The most common method of providing power to a fire pump is through an induction type AC electric motor (Figure 4-45) which operates at voltages less than 600 volts. However, in some installations, direct current motors of the stabilized shunt type or cumulative compound-wound type, or motors which operate at higher voltages than 600 volts, are used. Motors which operate at voltages higher than 600 volts introduce problems of personnel hazard, higher cost, and more complicated installation procedures. Motor controllers (Figure 4-46) for fire pump service are completely assembled in a self-supporting noncombustible structure. The controllers are arranged to start the fire pump manually, or automatically by a drop in water pressure or waterflow.

Electrical power supplies to fire pump motors and controllers should be arranged so that they are reliable and so that any outages which may occur are only momentary. Emergency power to fire pumps may be provided by an emergency generator with a transfer switch to switch the controller to the generator when an interruption occurs to the primary supply. (Using a generator is expensive. Internal combustion engine drivers are often employed.)

Engine drives (Figure 4-47) are usually provided when electrical power sources are unreliable or when the fire pump is for standby supplemental service. Engines powered by diesel fuel, gasoline, liquified petroleum gas, and natural gas may be in use for fire pump installations. However, only diesel engine drivers are acceptable in new installations. To prevent the engine from overheating, a closed pipe system with a heat exchanger is usually used for cooling. Typically, this cooling system is arranged to take water for cooling from the downstream side of the fire pump prior to the pump discharge valve (Figure 4-48). The exhaust from the engine must be piped to a safe point outside the pump room where personnel or property will not be endangered.

Fire pump engines should have a fuel supply sufficient for the engine to run for 8 hours. Engines use approximately 1 pint of fuel per horsepower per hour. The arrangement for a diesel engine fuel system is shown in Figure 4-49. The starters for internal combustion engines are powered from batteries. It is important to keep the batteries at full charge continuously. There are two means of recharging the batteries: one is by the alternator or generator on the engine, and the other is typically by a battery charger located in the controller.



1 NONREVERSE RATCHET prevents backspin when the power is turned off.

2 THRUST BEARING carries the weight of the shafting, impellers and hydraulic down-thrust. Angular contact design, 3 VERTICAL HOLLOW SHAFT motor or right angle gear drive is register aligned with the discharge head.

4 SHAFTING is high tensile steel and precision straightened. The head shaft is stainless steel,

5 STUFFING BOX seals off leakage around the shaft. Graphited asbestos packing is compressed around the shaft by an adjustable gland. A lantern ring relieves pump pressure back to the suction.

6 SURFACE DISCHARGE HEAD supports the column, shafting and pump assembly.

7 STEEL DISCHARGE COLUMN pipe ends are machine faced to provide a butt fit between pipe sections.

8 LINE SHAFT BEARING ASSEMBLY includes a cast bronze bearing retainer, fluted neoprene bearing and a stainless steel sleeve for long life.

9 STAINLESS STEEL PUMP SHAFT Medart polished and precision straightened.

10 BOWL BEARINGS in tandem provide a combination of bronze and the abrasion-resistance of neoprene.

11 BOWL WEAR RING prevents wear on the bowl.

12 INTERMEDIATE BOWLS maintain maximum efficiency and eliminate radial loads. Vitreous enamel linings available.

13 ENCLOSED BRONZE IMPELLER is precision cast and statically balanced.

14 TAPERED IMPELLER COLLET securely locks the impeller to the pump shaft.

15 PERIHEDRAL SEAL combines vertical cylindrical and horizontal surface impeller sealing for maximum efficiency.

16 SUCTION CASE BEARING is bronze and a minimum of five shaft diameters in length to stabilize the pump shaft,

17 BASKET STRAINER constructed of heavy gauge brass prevents clogging. A brass cone strainer is provided on deep well type pump installations

FIGURE 4-44
VERTICAL SHAFT TURBINE FIRE PUMP

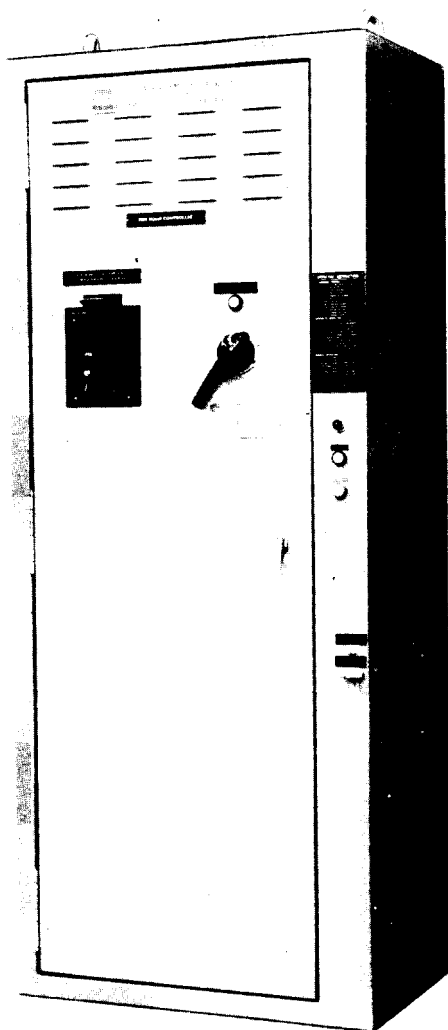


FIGURE 4-46
FIRE PUMP MOTOR CONTROLLER

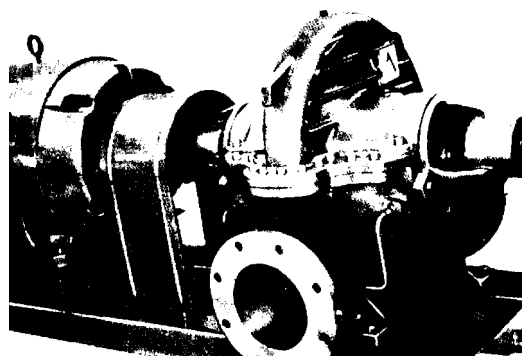


FIGURE 4-45
ELECTRIC MOTOR DRIVEN FIRE PUMP

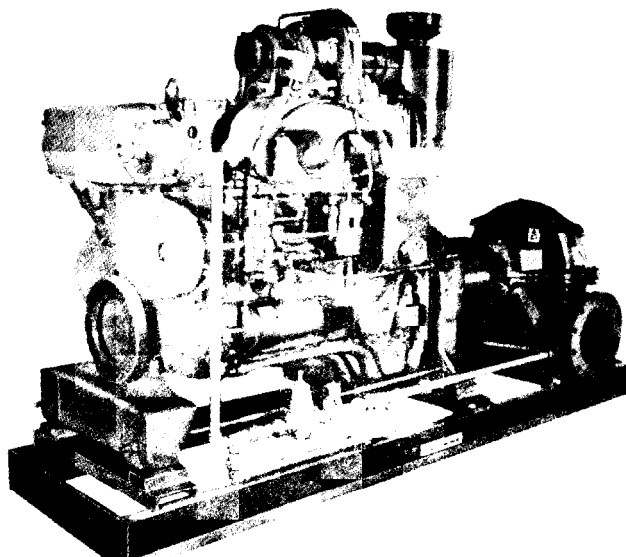


FIGURE 4-47
ENGINE DRIVEN FIRE PUMP

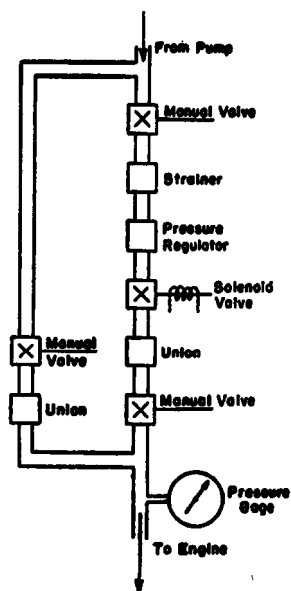


FIGURE 4-48
ENGINE COOLING WATER ARRANGEMENT

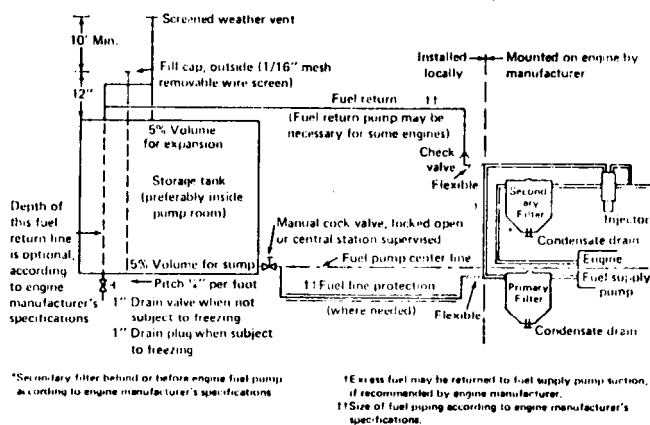


FIGURE 4-49
FUEL SYSTEM FOR DIESEL ENGINE
DRIVEN FIRE PUMP

Controllers for internal combustion engines (Figure 4-50) are similar to controllers for electric motor driven fire pumps in construction, electric wiring, and methods of actuation. They differ in the warning signals provided for the following malfunctions: failure to start, overheated engine (above 190°F), low oil pressure, and overspeed.

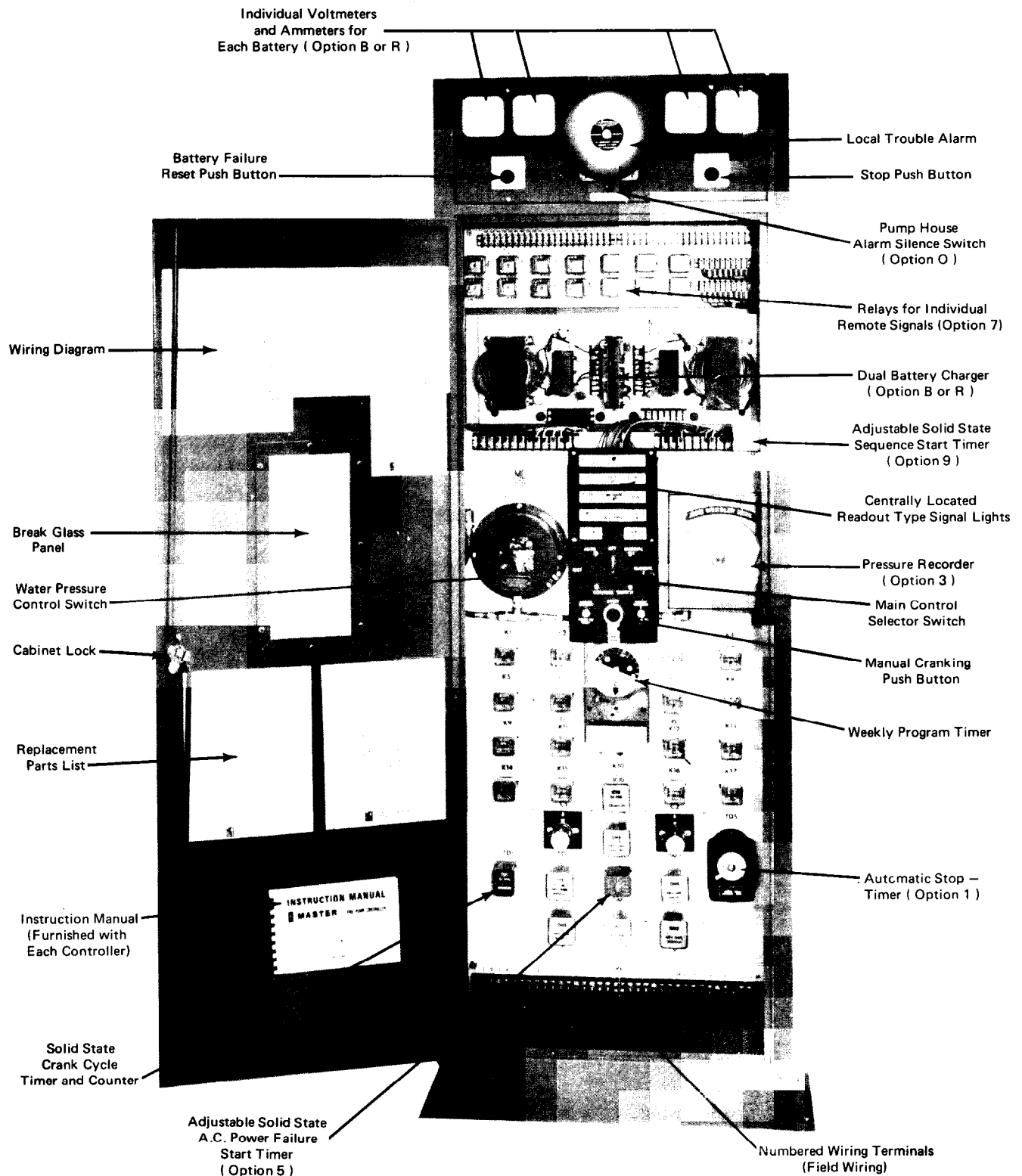


FIGURE 4-50
INTERNAL COMBUSTION ENGINE FIRE PUMP CONTROLLER

If the engine experiences overheating or low oil pressure, an alarm sounds but the engine continues to run until it is manually shut down or it self-destructs. Automatic shutdown occurs on overspeed at a speed approximately 15% above rated speed.

When adequate and reliable steam supplies are available, steam turbines are acceptable for use as drivers for fire pumps. Usually steam turbine driven fire pumps are manually controlled. To be acceptable for fire pump service, steam turbines must be able to drive the pump at rated speed and maximum pump load when steam is supplied at a minimum pressure of 80 psi. Turbines designed to operate at less than 80 psi are not acceptable for fire pump service.

4.3.4 Control Valves. Control valves in distribution systems allow portions of the system to be shut off without interrupting water service over a large area. Control valves can be nonindicating or indicating valves.

4.3.4.1 Nonindicating Control Valves. These valves are placed underground and require a key wrench for operation (Figure 4-51).

4.3.4.2 Indicating Control Valves. There are two main types of indicating control valves-post indicator and outside screw and yoke (OS&Y).

- Post indicator valves (Figure 4-52) are placed underground and have a post attached to them for operation and for visually inspecting the valve to see if it is open or shut. Post indicator valves are of the gate or butterfly type.

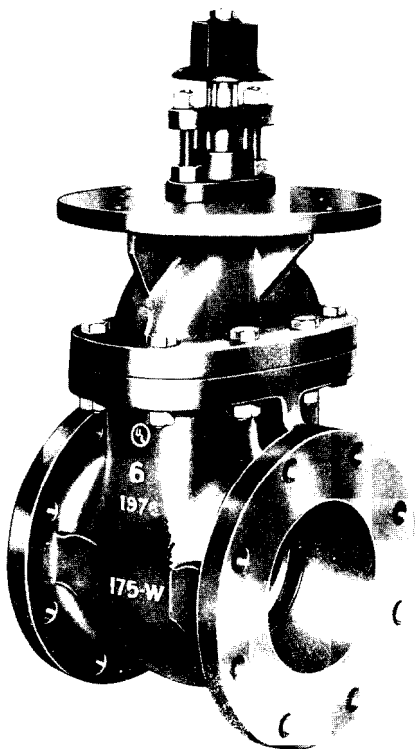


FIGURE 4-51
KEY OPERATED CONTROL VALVE

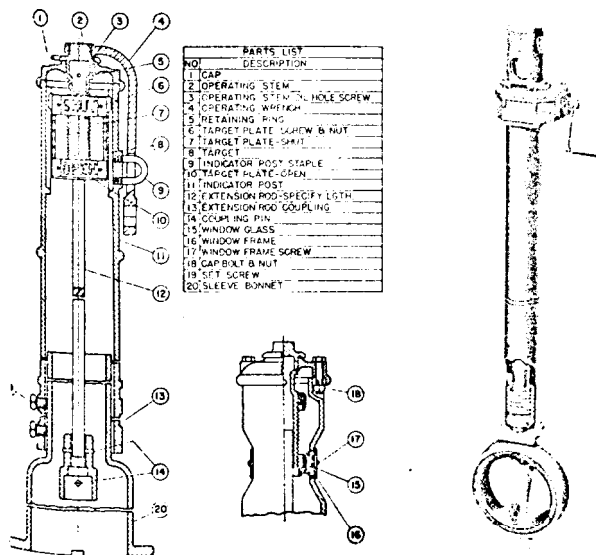


FIGURE 4-52
POST INDICATOR VALVES

The gate valve type post indicator has a target attached to the operating shaft inside the post. The target moves up and down as the operating shaft turns. This device, however, does not directly indicate the position of the gate valve. If the operating shaft breaks or if the target is misaligned, the target may give a false indication of the position of the valve. The butterfly valve type post indicator has an interior shaft inside the post attached directly to the butterfly mechanism in the valve. The butterfly valve target positively indicates if the valve is open, shut, or partially open.

- Outside screw and yoke gate valves indicate open or shut condition by a threaded operating stem attached directly to the gate portion of the valve (Figure 4-53). When the stem is exposed beyond the hand wheel, the valve is open.

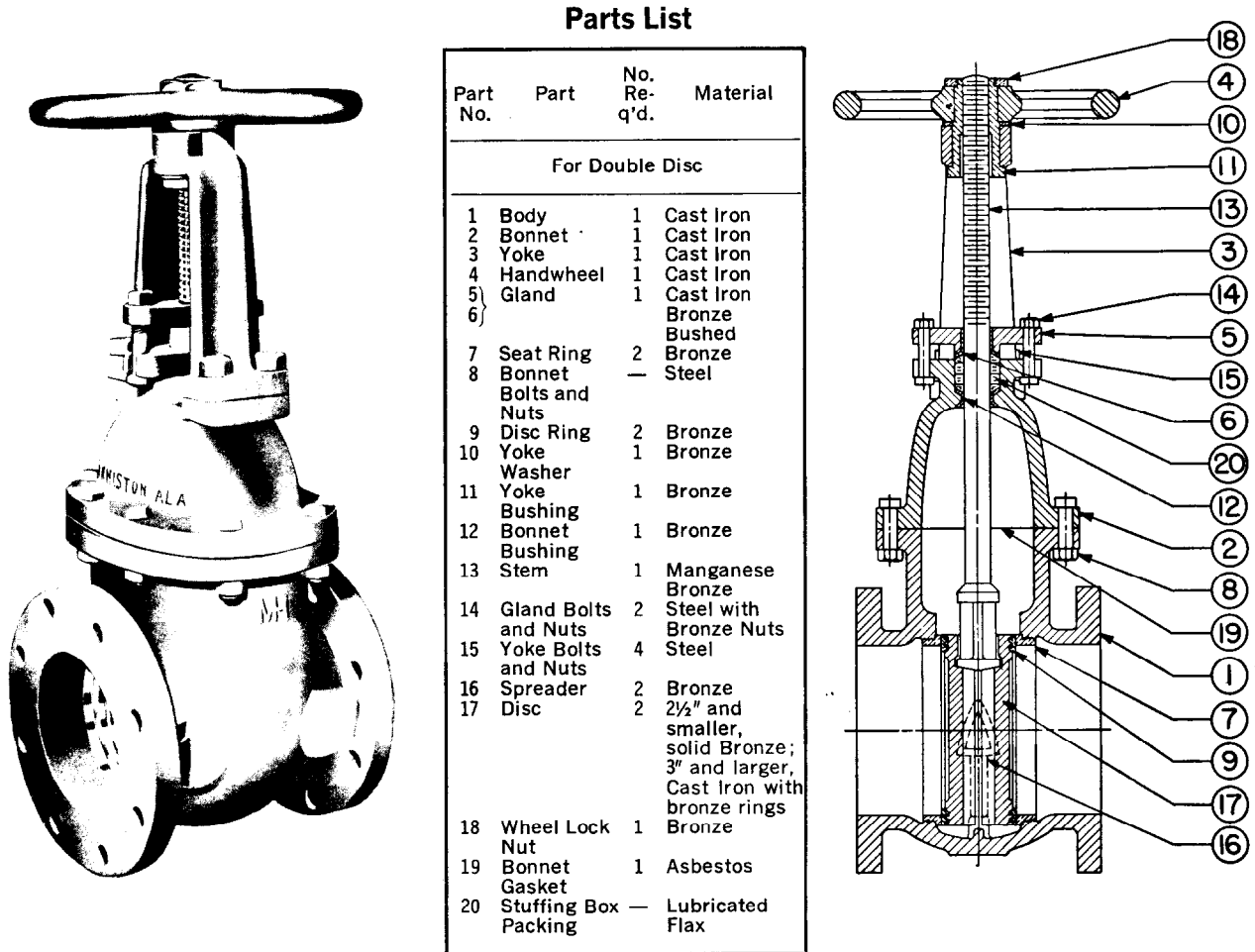


FIGURE 4-53
OS&Y GATE VALVE

4.3.5 Check Valves, Waterflow Meters, and Backflow Preventers. Check valves and backflow preventers allow water to flow only in a single, desired direction.

4.3.5.1 Check Valves. Check valves use a clapper inside a housing to allow water to flow in one direction. If water pressure increases from the opposite direction, the clapper closes and prevents flow.

- **Swing Valve.** A swing check valve (Figure 4-54) is the most common type of check valve. The clapper is installed in a valve body with a pivot point on one side. Water pressure from the upstream side of the valve forces the clapper open allowing the water to pass through the valve. In a no flow or reverse flow condition, the clapper closes against the seat to prevent backflow.

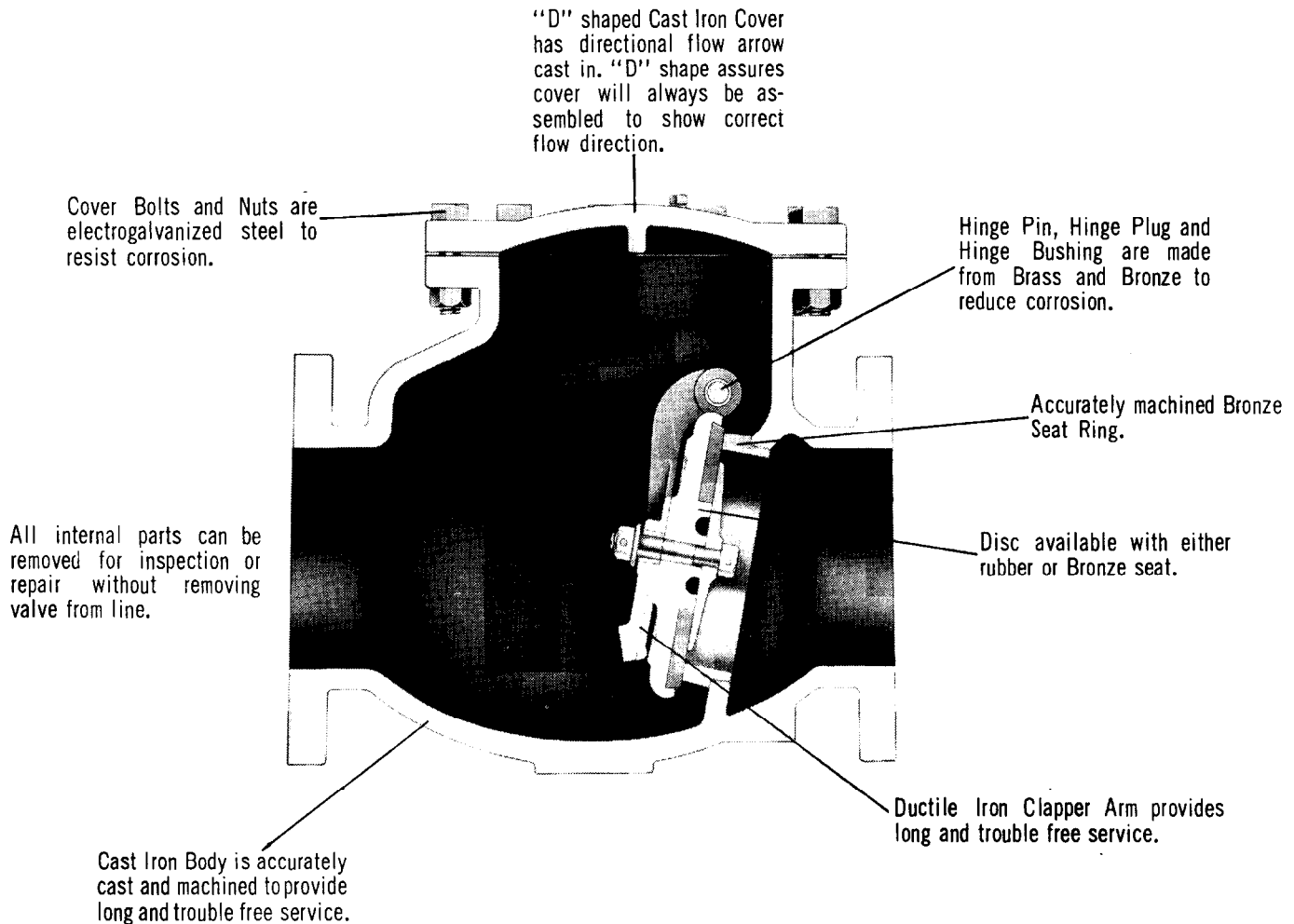


FIGURE 4-54
SWING CHECK VALVE

- **Wafer Check Valve.** A wafer check valve (Figure 4-55) has a split clapper held in the closed position by springs on each half of the clapper.
- **Double Check Valves.** A double check valve provides a higher degree of positive shut-off against backflow. The double check valve is essentially two swing check valves installed in series with a space between the two clappers (Figure 4-56).

Normally, a swing check valve closes tightly. However, occasionally leakage can occur due to improper maintenance or obstructions in the water lines which may hold the clapper open. In a double check valve arrangement, the probability that both valves will leak at the same time is remote.

Usually an 18-inch space between the clappers is sufficient to prevent materials in the waterpipe from holding both valves open. The greater the space between the two valves, the less the chance they will both be blocked open. If there is enough space, a 3- to 5-foot spacer can be placed between the two valves.

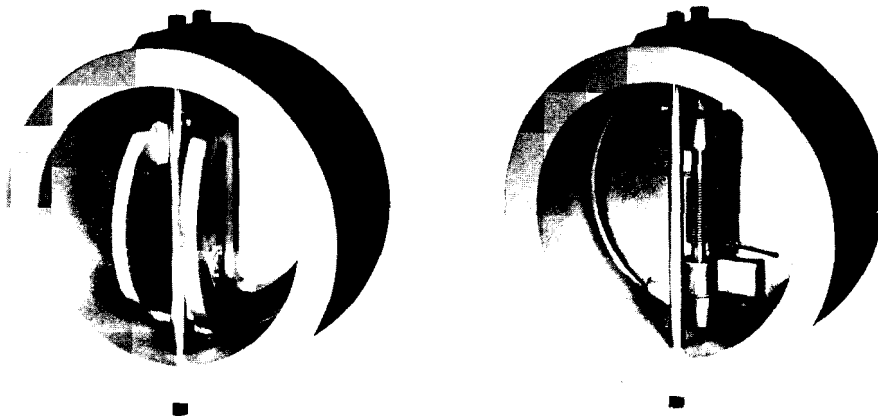


FIGURE 4-55
WAFER CHECK VALVE

4.3.5.2 Waterflow Meters. Waterflow meters are used to measure the amount of water passing through them.

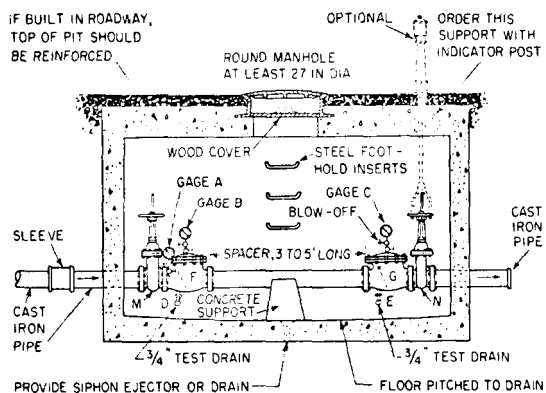


FIGURE 4-56
DOUBLE CHECK VALVE INSTALLATION

- **Detector Check.** A detector check valve (Figure 4-57) is a specialized check valve assembly to detect possible leakage or unauthorized use of water from sprinkler or standpipe systems. The detector includes a mainline check valve and a meter installed in a bypass around the valve. The check valve portion uses an internally weighted clapper which remains closed until there is a predetermined pressure loss. At low flow rates, all water flows through the bypass and is registered by the meter. With more

flow, the pressure loss increases until the loss reaches the predetermined value to open the mainline valve. When the mainline valve opens, a small portion of the water continues to be registered by the meter and the larger portion of the water flows through the mainline valve unmetered.

- **Full Registration Meters.** There are three different types of full registration meters. These meters have been designed *to* produce only a small friction loss which negligibly reduces the available water pressure to the sprinkler system with large flows.

Proportional Type. The proportional meter (Figure 4-58) is similar to a detector check in that a meter is installed in a bypass around the mainline valve. For small flows the operation is exactly the same as a detector check.

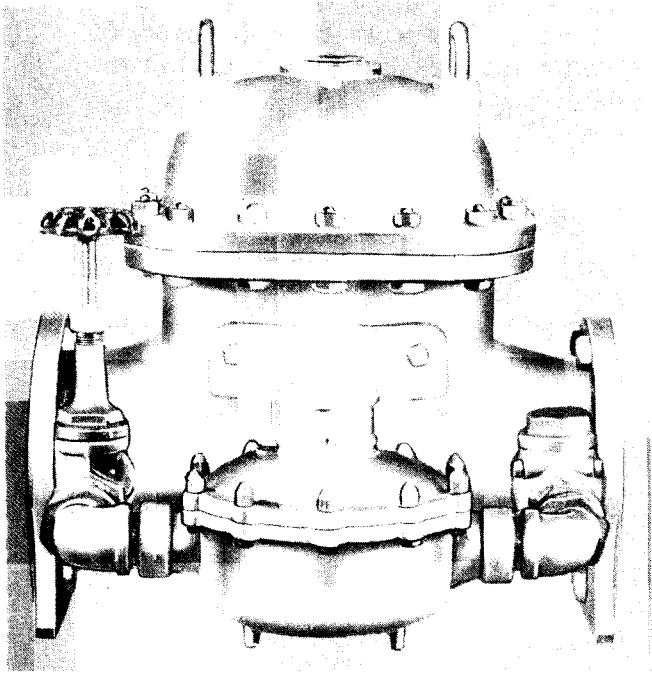


FIGURE 4-57
DETECTOR CHECK VALVE WITH METER
IN BY-PASS

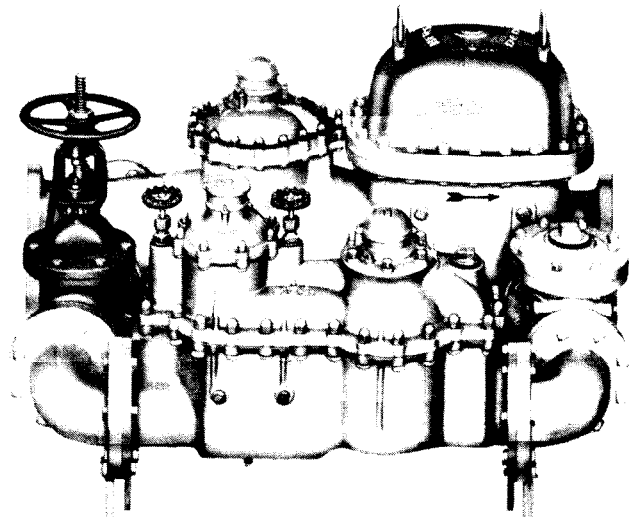


FIGURE 4-58
PROPORTIONAL TYPE FULL
REGISTRATION WATER METER

When the mainline valve opens, the water passing through the opening is slightly restricted by an orifice immediately ahead of the mainline valve. This orifice diverts a fixed percentage of the flow through a meter which is calibrated to record total flow through the line. The meter in the bypass continues to record waterflow after the mainline valve has opened. To determine total flow, the readings on both meters are added together.

Displacement Type. The displacement meter (Figure 4-59) is similar to the proportional meter except all working parts are located inside one casing. Two meters are provided, one on each side of the main waterway. For small flows, the water is channeled through an internal bypass and registered on one meter. With larger flows, the mainline valve opens, stopping the flow of water through the bypass and the mainline meter registers the flow. To determine total flow, the readings on both meters are added together.

Turbo Type. The turbo meter (Figure 4-60) is composed of two assemblies in one casing. The first assembly consists of straightening vanes to provide a smooth flow of water into the second assembly which is the measuring chamber. The measuring chamber contains a rotor, an adjusting vane, a pulse amplifier, and a terminal strip for attaching the connecting cable. As the rotor turns, the pulse amplifier sends signals to the register. When using a turbo meter, it is necessary to provide either a strainer or a straight piece of pipe (minimum length 15 pipe diameters) immediately ahead of the waterflow meter to assure valid registration.

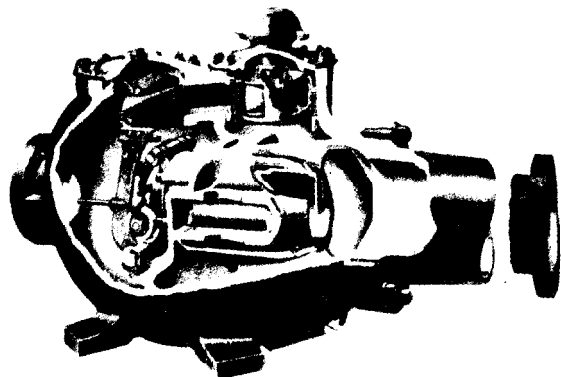


FIGURE 4-59
DISPLACEMENT TYPE FULL
REGISTRATION WATER METER

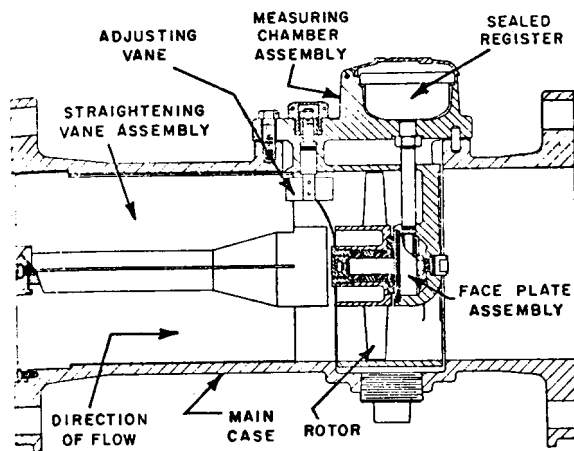


FIGURE 4-60
TURBO TYPE FULL REGISTRATION
WATER METER

4.3.5.3 Reduced Pressure Backflow Preventer. A reduced pressure backflow preventer is similar to a double check valve. An automatically operated pressure differential relief valve is installed between the two check valves. In case of leakage at either check valve, the relief valve maintains the pressure between the two check valves below the supply pressure to prevent backflow (Figure 4-61).

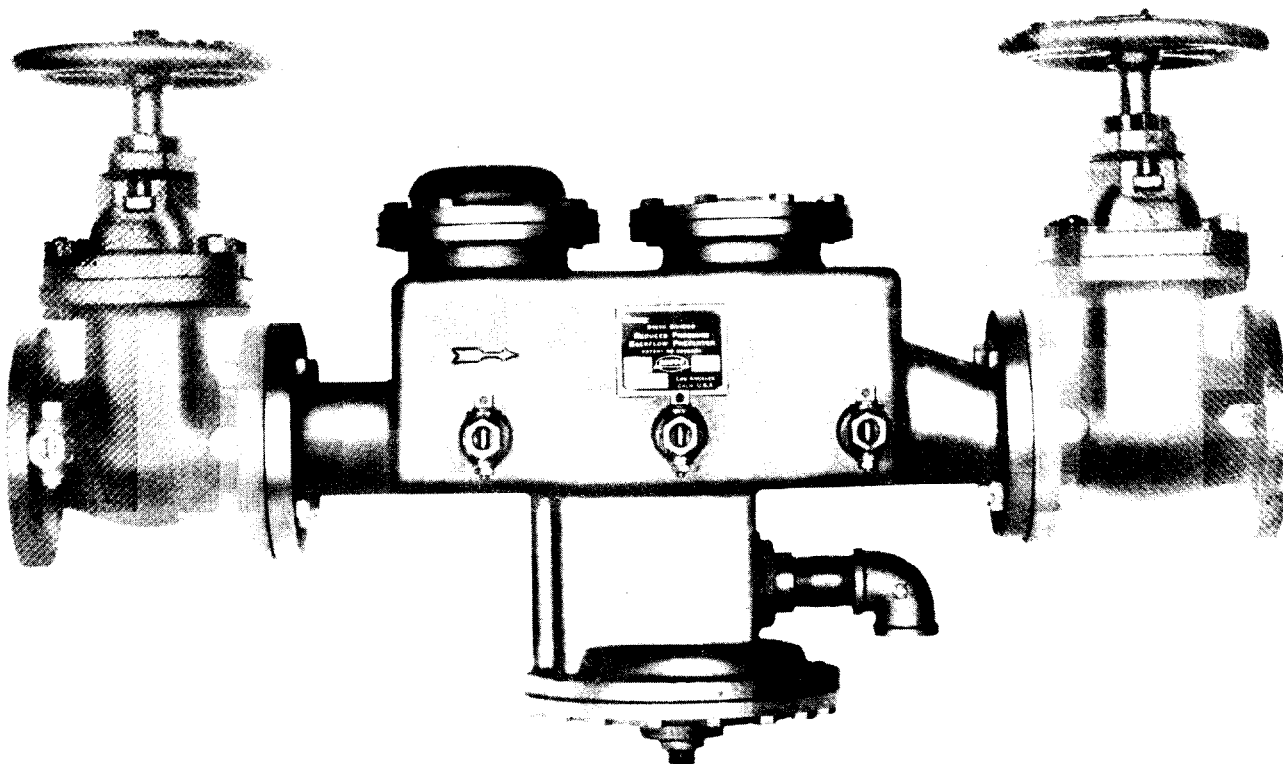


FIGURE 4-61
REDUCED PRESSURE BACKFLOW PREVENTER

4.3.6 Automatic Pressure Regulating Valves. Automatic pressure regulating valves are used in water supply systems to keep tanks from overflowing, reduce pressures, and bleed off enough water to prevent high pressures caused by surges. The more common types of pressure regulating valves are described in the following sections.

4.3.6.1 Float Valves. Float valves (Figure 4-62) are installed on tanks to shut off the water supply when the water rises to a predetermined level. The float can be adjusted to close the valve at the desired level in the tank. The valve seats will become damaged if the valve is held partially open for a long period of time. A large float and float arm is required with high pressure water supplies and ice and debris can interfere with valve operation.

4.3.6.2 Altitude Valves. Altitude valves, like float valves, shut off the water supply when it reaches a predetermined level. Altitude valves are self contained, except for the pressure sensing lines. Two basic types are available.

- Double-Acting Altitude Valves. A double-acting altitude valve (Figure 4-63) is usually installed on a tank where the supply pressure at the valve inlet is subject to fluctuations. The valve closes at the high water level and opens for return flow when pressure at the valve inlet drops below the tank water pressure created by the water level.

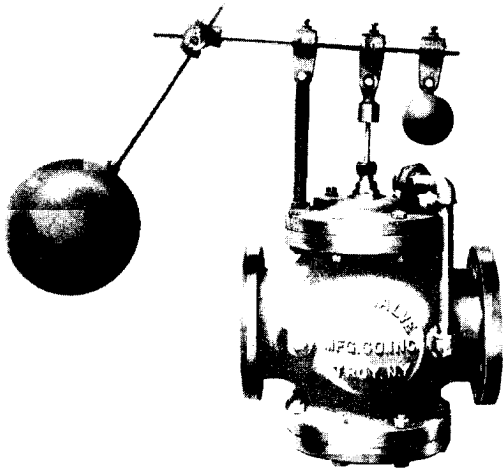


FIGURE 4-62
DIRECT ACTING LEVER OPERATED
FLOAT VALVE

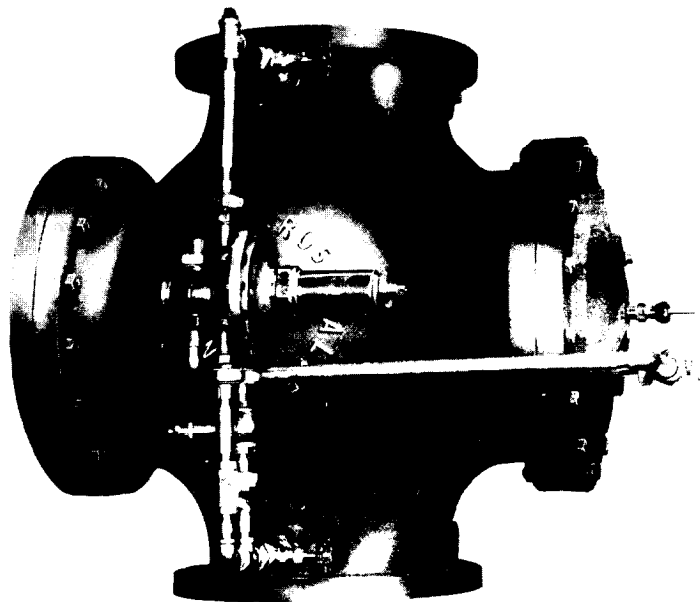


FIGURE 4-63
DOUBLE ACTING ALTITUDE
VALVE

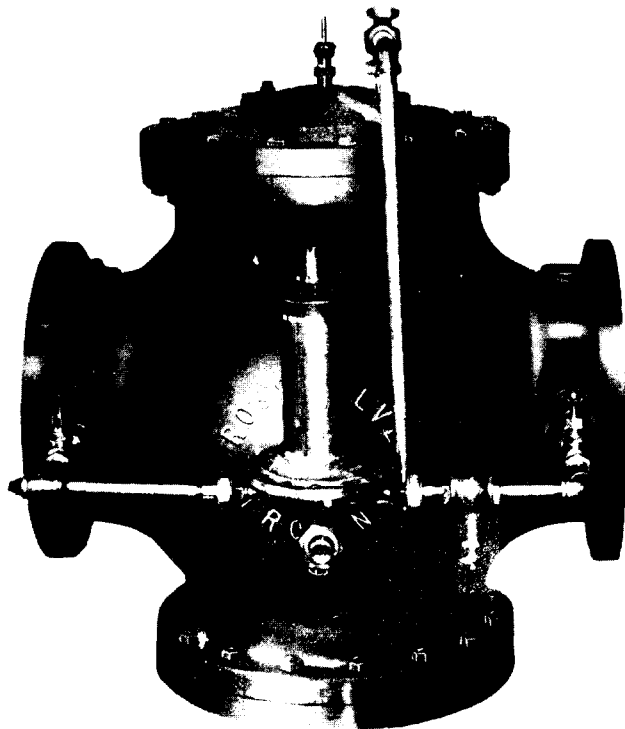


FIGURE 4-64
SINGLE ACTING ALTITUDE VALVE

- Single-Acting Altitude Valve. A single-acting altitude valve (Figure 4-64) is installed on a tank where the supply pressure at the valve inlet is constant and higher than the pressure created by the maximum reservoir level (head) . The valve closes when the water in the tank reaches its high water level. Water is withdrawn from the tank through a separate discharge line. When the water level drops below the shut-off level, the single acting altitude valve opens to refill the tank.

4.3.6.3 Pressure Reducing Valves. Pressure-reducing valves (Figure 4-65) throttle the flow of water in pipes to keep the pressure at the discharge side constant, regardless of the rate of flow and pressure at the inlet. These valves are sometimes used as altitude valves. If a great variation in the rate of flow is expected, pressure-reducing valves of different sizes may be installed in groups and adjusted so they come into operation from the smallest to largest as the flow rate increases. This causes only a slight variation in discharge pressure between maximum and minimum flow rates. Some pressure-reducing valves can be set too sensitively. When this happens, the valve reacts so rapidly that it causes a surge.

4.3.6.4 Pressure Relief Valves. Pressure-relief valves (Figure 4-66) discharge water from pipes or systems when a maximum desired pressure is exceeded. They are installed on low pressure systems which are fed through pressure-reducing valves from high pressure supplies to prevent damage if the pressure-reducing valves fail to operate correctly. These valves are also used on fire pump headers. Relief valves are essentially pressure-reducing valves in which the control mechanism responds to pressure on the inlet side rather than the outlet end.

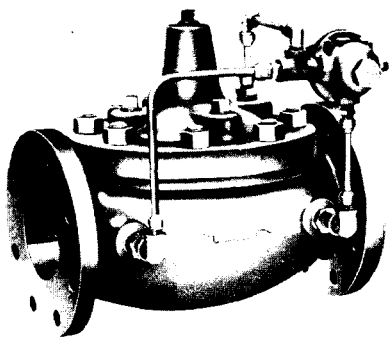


FIGURE 4-65
PRESSURE REDUCING VALVE

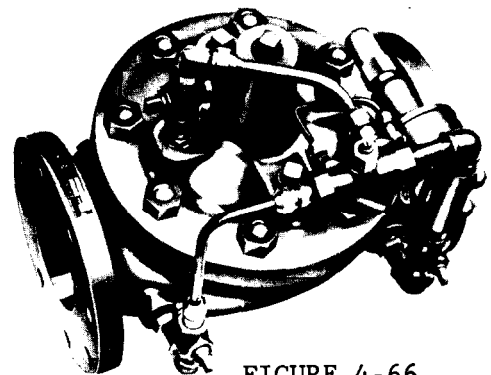


FIGURE 4-66
PRESSURE RELIEF VALVE

CHAPTER 4. SELF-STUDY QUESTIONS

Instructions: Select the correct answer(s) for each of the following questions.

- Q4-1 The three basic components of a sprinkler system are:
- a. Water control valve(s)
 - b. A piping network
 - c. A fire pump
 - d. A water supply
 - e. Sprinklers
- Q4-2 The part of a sprinkler which breaks up water into droplets is called a deflector.
- a. True
 - b. False
- Q4-3 Sprinkler temperature ratings are sometimes identified by the color of the sprinkler frame. A blue frame signifies a temperature rating of:
- a. 165°F
 - b. 212°F
 - c. 220°F
 - d. 286°F
- Q4-4 An uncolored sprinkler signifies a temperature rating of:
- a. 165°F
 - b. 212°F
 - c. 220°F
 - d. 286°F
- Q4-5 The most common type of sprinkler system is a:
- a. Dry pipe system
 - b. Lawn sprinkler system
 - c. Wet pipe system
 - d. Pre-action system
- Q4-6 Water should never be allowed inside a dry pipe valve.
- a. True
 - b. False
- Q4-7 A differential dry pipe valve has a nominal water to air ratio of:
- a. 6:1
 - b. 3:1
 - c. 8:1
 - d. 2:1

- Q4-8 The device(s) used to speed the operation of a dry pipe valve is called a:
- a. Quickie
 - b. Speedster
 - c. Accelerator
 - d. Exhauster
 - e. Bleeder
- Q4-9 A low differential dry pipe valve is required to have an air maintenance device.
- a. True
 - b. False
- Q4-10 An air check valve is similar to a dry pipe valve.
- a. True
 - b. False
- Q4-11 In a pre-action sprinkler system, all sprinklers operate at the same time.
- a. True
 - b. False
- Q4-12 A supervised pre-action sprinkler system is one in which:
- a. A fire alarm system is provided to signal that water is flowing
 - b. The piping is filled with air to detect leaks
 - c. The control valves are supervised to insure that they are open
 - d. None of the above
- Q4-13 A pre-action and a dry pipe sprinkler system are the same.
- a. True
 - b. False
- Q4-14 A combined system uses two different types of extinguishing agents.
- a. True
 - b. False
- Q4-15 Rapid reaction fire suppression systems operate in times less than:
- a. 1 second
 - b. 5 seconds
 - c. 10 seconds
 - d. 1 minute
- Q4-16 The watermotor alarm has a connection to an electrical power supply to operate.
- a. True
 - b. False

- Q4-17 Class II standpipe systems are for fire department use with 2-1/2-inch hose.
- a. True
 - b. False
- Q4-18 Water supplies for sprinkler and standpipe systems must be adequate and reliable.
- a. True
 - b. False
- Q4-19 Wet barrel fire hydrants are used in areas subject to freezing.
- a. True
 - b. False
- Q4-20 Fire department connections are used by the fire department to supply water for fire hose streams.
- a. True
 - b. False
- Q4-21 Water tanks for fire service do not require heat.
- a. True
 - b. False
- Q4-22 Corrosion in water tanks is usually first identified by rust.
- a. True
 - b. False
- Q4-23 To prevent corrosion of water tanks:
- a. Chemical rust inhibitors are added to the water
 - b. Tanks are painted regularly
 - c. Cathodic protection is used
 - d. Tanks are heated
 - e. All of the above
- Q4-24 Multiple stage pumps are suitable for fire service,
- a. True
 - b. False
- Q4-25 A circulation relief valve:
- a. Prevents overpressurization of a fire pump
 - b. Prevents overcirculation to a fire pump
 - c. Prevents overheating of a fire pump
 - d. Prevents contamination of the water supply at a fire pump
- Q4-26 A hose header is used for:
- a. The fire department to connect hoses to in the event of a fire
 - b. Testing fire pumps
Drying fire hoses
 - c. Supplying automatic sprinklers in the event of a fire

Q4-27 A pitot tube measures:

- a. Pressure
- b. Pitots
- c. Water quality
- d. Water level in a tank

Q4-28 A right angle gear drive is used to transmit power from an engine driver to a fire pump which is around the corner from the driver.

- a. True
- b. False

Q4-29 Controllers for engine drivers and electric drivers are interchangeable.

- a. True
- b. False

Q4-30 The minimum pressure at which a steam turbine may be operated in order to be acceptable for fire pump service is:

- a. 50 psi
- b. 80 psi
- c. 100 psi
- d. 125 psi

Q4-31 A butterfly type post indicator valve directly indicates the open position of the valve.

- a. True
- b. False

Q4-32 Outside screw and yoke valves are:

- a. Located outside, underground, and require a key wrench for opening
- b. Used outside in conjunction with a post indicator
- c. Nonindicating
- d. None of the above

Q4-33 Check valves are backflow preventers.

- a. True
- b. False

Q4-34 Altitude valves prevent water tanks from overflowing.

- a. True
- b. False

Q4-35 The most frequent cause of sprinkler system failures is:

- a. Improper design of the system
- b. Increased hazard within the building
- c. Closed water supply valves
- d. Failure of fire pumps
- e. Frozen water tanks and sprinkler piping

Q4-36 A heat-actuated device (HAD) operates on the principle that:

- a. Heated ice melts
- b. Gases can be compressed
- c. Mercury is heavier than water
- d. Heated air expands

Q4-37 Mercury checks are provided to subdivide several HADs into small groups so that:

- a. The location of the fire can be identified
- b. The pressure developed in a few HADs will not be absorbed by other HADs
- c. The installing contractor can justify additional money for the installation
- d. None of the above

Q4-38 A compensating vent of an HAD system is provided to:

- a. Allow a time delay on system actuation
- b. Prevent odors from accumulating
- c. Prevent system actuation due to atmospheric changes
- d. Provide an air supply into the air tubing

Q4-38 Residential sprinkler systems include sprinkler

- a. Heads which are faster responding with unique water distribution characteristics
- b. Plastic pipe
- c. Small diameter pipe
- d. All of the above

CHAPTER 5. INSPECTION, TESTING, AND MAINTENANCE OF AUTOMATIC SPRINKLER AND STANDPIPE SYSTEMS

5.1 GENERAL. Sprinkler and standpipe systems, when properly installed, are an effective means of protecting life and property against fire. To insure the reliability of these systems, periodic inspection and maintenance of the individual components of the systems is required.

Inspection for each major component of the fire protection system should include a visual inspection and, if practical, a test of the component to assure its working condition. Regular service contracts with the manufacturer or installer are recommended. The frequency of the overall testing and inspection process is summarized in Table 5-1.

As with all fire protection systems, be certain that sprinkler and standpipe systems are restored to normal operating condition after inspection, testing, and maintenance. The use of a maintenance log is suggested.

5.2 AUTOMATIC SPRINKLERS. Inspection for automatic sprinklers consists of an annual visual observation of the unit. The physical condition affects the ability of the sprinkler to perform. Review obstructions of the heat flow to the sprinkler and of the proper water discharge pattern from the sprinkler.

If inspection of sprinklers reveals damage, replace the affected sprinklers. Sometimes, sprinklers need to be relocated or replaced. When removing or installing sprinklers always use a sprinkler wrench. Other wrenches may damage the sprinklers. Be certain that replacement sprinklers are of the same style, orifice size, temperature rating, coating, deflector type and RTI unless an engineering evaluation dictates otherwise. Upright and pendent sprinklers are not to be interchanged.

The identification of hydraulically designed systems should be present at the sprinkler riser. The identifying label should include the design basis, such as design pressure, area of operation and density.

Some of the conditions that affect sprinklers and remedial actions are:

- Mechanical injury such as bent or loose deflectors or bent frames. Where subjected to continual damage, provide approved sprinkler guards.
- Corrosion-marked discoloration or hard deposits. Use lead-coated or wax-coated sprinklers to prevent corrosion,
- Overheating-giving way of soldered joints and cracked quartz bulbs. Temperature ratings for soldered link and quartz bulb sprinklers should be 50°F and 25°F above normal room temperature, respectively.
- Freezing-reduced tension in soldered links, bent struts, and distorted caps. Replace sprinkler head.
- Loading-deposits of paint or other foreign materials. Where directly exposed to such deposits, sprinklers should be replaced annually.

TABLE 5-1
SUMMARY OF INSPECTION AND TEST FREQUENCIES FOR
SPRINKLER AND STANDPIPE SYSTEMS

Item	Weekly	Bi-Monthly	Quarterly	Annually	EVERY 3 YR
1. Check general condition of sprinklers and sprinkler systems				x	
2. Conduct flow tests of open sprinklers				x	
3. Conduct main drain tests			x		
4. Test waterflow alarms			x		
5. Check air and water pressure in dry pipe systems			x *		
6. Trip test dry pipe valves				x	
7. Drain low points in dry pipe system				x	
8. Trip test deluge and pre-action systems					x
9. Trip test high speed suppression systems					x
10. Check condition of standpipe system				x	
11. Perform waterflow tests from water mains			x *		
12. Check general condition of hydrants				x	
13. Check general condition of fire department connections			x		
14. Check water levels in tanks			x *		
15. Check condition of water storage tanks			x *		
16. Check water level and air pressure in pressure tanks		x			
17. Check condition of pressure tanks				x	
18. Check tank heating systems				x	
19. Inspect and test cathodic protection equipment				x	
20. Start fire pumps		x			
21. Check fuel supply to engine drivers		x			
22. Perform fire pump flow tests				x	
23. Inspect and test controllers				x	
24. Inspect control valves for open position			x *		
25. Conduct general preventive maintenance inspection of valves				x	
26. Inspect check valves, waterflow meters, and backflow preventers			x		
27. Test pressure regulating and altitude valves				x	

* For Supervised system, inspection can be performed annually or during routine facility inspections, whichever is more frequent.

- Major construction and occupancy changes, and changes to heating, lighting, and air conditioning systems may require relocation or 10 replacement of sprinklers or additions to the system. Changes in sprinkler location and pipe sizes should be based upon an engineering evaluation.
- Protection of commercial-type cooking equipment check semi-annually. Replace the heads annually.
- Stock piling-a clearance of at least 18 inches under sprinklers is necessary for proper water distribution.
- Extra sprinklers-Keep a supply of extra sprinklers for the various types and temperature ratings required, and a sprinkler wrench. Spare sprinklers should be kept in a dry area, with a temperature less than 100°F and not exposed to dust or corrosion. Refer to Table 5-2 for guidance on the number of spare sprinklers which should be available.

TABLE 5-2
SPARE SPRINKLER SUPPLIES

Total Number of Sprinklers in Building	Minimum Number of Spare Sprinklers
1 - 300	6
301 - 1000	12
1001 or More	24

5.3 OUTSIDE OPEN SPRINKLERS. Outside open sprinklers are sometimes obstructed by material in the orifice. Perform the following annually.

- Visually check general condition of sprinklers.
- Close windows and doors and take proper precautions to avoid water damage to property before flow tests.
- Conduct flow tests by opening the control valve.
- After flow tests, remove and clean plugged or obstructed sprinklers.

5.4 PIPING AND HANGERS. Inspect piping and hangers annually for the following:

- Mechanical injury and corrosion. Replace bent or damaged piping and fittings and replace or repair missing or loose hangers.
- Make sure that piping is not used to support stock, equipment, or other material.
- Make sure wet pipe system piping is properly protected against freezing.
- Before and during freezing weather, check piping of dry pipe systems for proper drainage.

- During freezing weather, open drains for outside sprinkler systems,
- Drain water from low point drains and drum drips on dry pipe systems before freezing weather occurs.

5.5 OBSTRUCTED PIPING. To find evidence of obstructions in piping, check for the presence of stones, scale, mud, or other foreign material in water discharged during 2-inch drain tests or inspector test. To determine the extent and type of obstruction.

1. Tie a burlap bag over the discharge outlet of the 2-inch drain.
2. Allow a full flow from the 2-inch drain for 3 to 5 minutes or until water runs clear.
3. Examine the contents of the bag.

When evidence of obstruction has been found, check for the following sources of obstructing material:

- Improperly screened inlets from open bodies of water.
- Poorly maintained elevated gravity tanks.
- Dead end of extensive water distribution systems,
- Poorly installed underground mains.
- Highly acid, alkaline, or saline water.
- Active chemicals in water supply.
- Use of second-hand materials in the sprinkler system.
- Frequent operation of systems, especially dry pipe systems, introducing additional foreign material and free oxygen.

5.6 FLUSHING SPRINKLER SYSTEMS. Finely divided materials, such as sand, will wash through a sprinkler opening. However, if deposits are becoming solidified, or if stones, cinders, and the like are present, flush the sprinkler system. There are three methods of flushing obstructed piping in sprinkler systems.

5.6.1 Hydraulic Method. The hydraulic method is the most common and least expensive method of the three. Waterflow in the system is in the same direction as when the system normally operates--from the riser to the open fitting. Before flushing the sprinkler systems, clear the water supply piping of any foreign materials which might be brought into the sprinkler system (See the procedures on flushing underground water mains, section 5.18). In multi-story buildings, systems should be flushed by starting with the lowest story first and working up.

When flushing dry pipe systems, the system should be filled with water for 1 or 2 days before flushing to allow the pipe scale and deposits to soften. Drain the system and reset the dry pipe valve before flushing continues. Flush cross mains first by attaching 2-1/2-inch fire hose and valves at the ends of the cross mains. To prevent kinking of the fire hose, install an elbow between the end of the cross main and the 2-1/2-inch hose valve.

After feed mains and cross mains have been thoroughly cleaned, flush branch lines. Fit the ends of branch lines with valves and flush individual lines of the group consecutively. (This will eliminate having to shut off and drain the system for each individual branch line being flushed.) Remove all pendent sprinklers, after flushing has been completed, and remove any foreign materials from the sprinklers and associated piping.

5.6.2 Hydropneumatic Method. The hydropneumatic method requires special equipment including a 30-gallon water tank connected to a 25-gallon air tank. Waterflow is from the end of the system back toward the riser. Because of the specialized equipment and procedures required when using this method, it should be performed by qualified sprinkler contractors only.

5.6.3 Mechanical Methods. Infrequently, deposits are too hard to remove by hydraulic methods. In these cases, deposits are removed by hand rodding or air driven cutter heads used by qualified and experienced contractors. If checking shows excessive deposits of this type, replacement with new piping is usually less expensive than cleaning by mechanical means.

5.7 ALARM CHECK VALVES. Perform a 2-inch drain test quarterly to test alarm check valves. Open the 2-inch drain valve fully and record pressure on the gauge located below the clapper at lowest point and close the 2-inch drain valve and record pressure at stabilization point. Notice whether pressure returns quickly or slowly. Maintain a continuous record of drain tests. If the recorded pressure with the valve wide open is similar to previous recordings and the pressure returns quickly when valve is closed, it is normal. Otherwise, there may be an obstruction in the waterway. Check for:

- Partially closed valves to sprinkler system
- Obstruction in alarm valve preventing clapper from opening freely

Test local waterflow alarm operation quarterly by opening the test connection at the end of the system. Where there is no test connection, the alarm may be tested by opening the bypass valve to the circuit opener or closer or by opening the 2-inch drain valve about 2-1/2 turns. Do not test water motor alarms during freezing weather. To find principal causes of alarm failures, check for the following:

- Failure of automatic drain on retard chamber to close.
- Closed or partially closed valve on piping to alarm devices.
- Plugging of bell casings of water motor gongs by foreign material.
- Corrosion of moving parts of water motor gongs.
- Detachment of shaft couplings from water motor gongs.

- Insufficient water flow to operate devices.
- Alarm check valve corroded shut. (This type of failure is not common and will not occur when systems are properly maintained.)

To find principal causes of false fire alarms, check for the following:

- Improper drainage of retard chamber. (Correct this by opening chamber and cleaning or repairing automatic drain.)
- Pressure surges through the alarm check valve.

Fill wet pipe sprinkler systems slowly through throttled valves and open the control valve-wide after system has been filled. Be sure there is no drainage from retard chambers, Leakage means that the alarm valve clappers are not seating properly and require cleaning and possibly overhauling.

Make internal inspections of alarm valves when normal testing procedures indicate the need.

- Examine valve body for tuberculation.
- Check clapper operation--the clapper should move freely without sticking or binding.
- Replace clapper facings as required.
- Resurface seat rings as required.

5.8 DRY PIPE VALVES AND AIR CHECK VALVES. Air check valves are special, small, dry pipe valves which are usually connected to a wet pipe system. The alarms are actuated at the wet pipe system riser when the air check valve "trips". To prevent premature operation, the valves should be fitted with an air chamber to maintain at least 50 gallons of air in the chamber and on the system. The water flow and low air pressure alarms should be tested along with a water flow test using the main drain on a quarterly basis.

Perform the 2-inch drain test by opening the 2-inch drain valve fully and recording pressure at lowest point. Close the 2-inch drain valve and record pressure at stabilization point. Notice whether pressure returns quickly or slowly. Maintain a continuous record of drain tests. If recorded pressure when the valve is wide open is similar to previous recordings and pressure returns quickly (in a matter of seconds) when the valve is closed, it is normal. Otherwise, there may be an obstruction in the waterway. Check for partially closed valves to the sprinkler system.

Because dry pipe sprinkler systems are installed in areas which are expected to drop below freezing temperatures, all parts of the system must be air tight and kept free of water. Complete drainage is essential. Each fall, before freezing season comes, check the pitch of all piping carefully using a split level to detect dips and small pockets in the lines. Check for:

- Broken, loose, or missing hangers.
- Water in low point drains.

Check air or nitrogen, and water pressures weekly. If air or nitrogen pressure losses exceed 10 psi, check the entire system for tightness and eliminate air leaks. Principal checking methods are:

- Put a strong smelling oil, such as oil of peppermint, into the air supply. This will produce a strong odor at the point of leakage.
- Paint fittings with a soapy water solution and watch for bubbles.

Check temperature of valve enclosure and maintain a temperature above 40°F. Make certain that the valve between the intermediate chamber and the alarm devices is open on dry pipe valves.

Check drip valves at intermediate chambers, making certain that clappers or balls are in a position to allow drainage. This is done by lifting push rods or by inserting a pencil in the opening. Water leakage through this valve is an indication that the water clapper is not holding tightly to the seat.

Check the air pressure. The air pressure versus water pressure for differential dry pipe valves should be as outlined in Table 5-3, unless otherwise specified by manufacturers' operating instructions. Certain mechanical type dry pipe valves are designed to trip at a fixed pressure of 10 to 15 psi. Maintain 30-psi air pressure on these valves.

TABLE 5-3
DIFFERENTIAL DRY PIPE VALVE AIR PRESSURE SPECIFICATIONS

Maximum Water Pressure (psi)	Air Pressure Range (psi)
50	15-25
75	20-30
100	25-35
125	30-45
150	35-50

Basic inspections for accelerators and exhausters include the following:

- Check air pressure. System and quick-opening device air pressure should be the same.
- Relieve excess pressure in quick-opening device by opening bleeder valves or loosening air gauges.
- If system pressure is high, relieve the excess pressure through the priming water test valve. Close this valve as soon as pressures balance. To avoid the possibility of tripping the dry pipe valve, do not open the priming test valve more than one turn and keep the valve to the quick-opening device closed while the priming test valve is open.

To insure that dry pipe valves will operate effectively in fire situations, they should be trip tested annually (in the spring) as follows:

1. Close main control valve.
2. Open 2-inch drain.
3. Open main control valve until 5 pounds pressure shows on the water gauge.
4. Close 2-inch drain valve slowly.
5. Open inspector's test connection of the system. Where there is no test connection, use the most remote low point drain.
6. As soon as the dry pipe valve trips, close the main control valve and open the 2-inch drain. This is particularly important in permanently cold areas.
7. Record initial air and water pressures, air pressure at the trip point, and time required for tripping.
8. Examine and clean dry pipe valve interior. Replace facings and gaskets if needed.
9. Reset dry pipe valve and open control valve.
10. When a dry pipe valve fails to trip or when a clapper fails to latch in the open position, notify the person responsible for fire protection so that a qualified sprinkler contractor may be contacted.

To reset dry pipe valves:

1. Close main control valve and open the 2-inch drain valve and low point drain valves. Close low point drain valves when water stops flowing.
2. Clean clapper facings and seats.
3. Clean valve interior.
4. Place clappers on seats and make certain the anti-water column latch is in place. Bolt on the cover. Do not use grease or other material to help seat clappers. Fill the system with 10-psi air pressure to blow out any residual water through low point drains.
5. Open valves at the top and bottom of the priming chamber and priming test valve.
6. Admit water to the priming chamber until water flows out of test valve. Close this valve.
7. Close the priming chamber valves.
8. Admit air pressure to the system.
9. Open the main control valve slowly.

10. Close the main 2-inch drain valve, except where water hammer conditions exist. In this case, leave the 2-inch drain valve open until pressures stabilize.

To check air supply piping, use the following procedure:

1. Note air pressure within 12 to 24 hours after resetting the dry pipe valve. If air leakage exists, test sprinkler piping for leaks.
2. Make sure the valves to manually operated compressors are tightly closed. A slow air leak back through one of these valves can result in tripping the dry pipe valve.
3. Examine restriction orifices in air piping and air pressure regulators, if used, from automatic air compressors to dry pipe valves,

5.9 ANTIFREEZE SYSTEMS. No special testing of antifreeze systems is required, other than an annual check of the specific gravity of the antifreeze solution. Characteristics of the most common antifreeze solutions are listed in Table 4-2. If the specific gravity indicates a need for replenishing the antifreeze agent, be sure to add the same agent as previously used.

5.10 DELUGE AND PRE-ACTION VALVES. Perform the 2-inch drain test quarterly by opening the 2-inch drain valve fully and recording pressure at the lowest point. Close the 2-inch drain valve and record pressure at the stabilization point. Notice whether pressure returns quickly or slowly. Maintain a continuous record of drain tests.

If recorded pressure when valve is wide open is similar to previous recordings and pressure returns quickly when valve is closed, it is normal. Otherwise, may be an obstruction in the waterway. Check for partially closed valves to sprinkler system. Check:

- Water pressure
- Local waterflow alarm through bypass connection

Some deluge systems have both open and closed sprinklers. Make sure operational heat-responsive devices are provided in areas with both open and closed sprinklers and are in service. Fusing of a sprinkler will not operate a deluge valve. Where conditions permit, trip test each deluge valve every 3 years with the control valve open. To trip test deluge valve:

1. Close main control valve.
2. Apply an electric heat lamp to at least one heat actuating device in each circuit, testing one circuit at a time. Note the time required to trip the valve. Where flammable vapors may be present, use a hot cloth or hot water in place of the electric test set.
3. Reset the deluge valve and trip, using the manual release.
4. Where fixed temperature releases are involved, wait 15 minutes and trip by removing a fusible element from the tubing or a heat-responsive device.

5. When tests are complete, reset valves and open the main control valves.

Detectors should be tested semi-annually and alarms quarterly. Because there are so many designs of heat responsive devices, test procedures for each cannot be included here. See individual manufacturers' information for detailed testing procedure. During routine inspections, check for painted or corroded contacts, plugged vents, or painted domes. Clean or replace affected devices.

5.11 HIGH SPEED SUPPRESSION SYSTEM. Perform a full operational test of high speed suppression systems every 3 years by actuating a detector (see Chapter 3), or by actuating a manual release station. Check to be certain that all nozzles are operating. Then, follow these steps to reset the system:

1. Replace pre-prime caps and/or rupture discs.
2. Refill piping with water.
3. If system uses an explosive valve, replace the firing squib and the squib holder.

5.12 STANDPIPE AND HOSE CONNECTIONS. Annually or when routine facility inspections are performed (whichever is more frequent), check standpipe and hose connections. Check for the following:

- Hose valves are tight.
- Hose and hose racks or reels are in good condition (re-rack hose annually.)
- Hose is dry and easily moved,
- Stored hose nozzles are unobstructed.
- Threads on nozzles and couplings are in good condition.
- Hose and nozzle gaskets are tight.

5.13 INTERRUPTIONS TO SPRINKLER AND STANDPIPE SYSTEM PROTECTION. To minimize the effect of an interruption of sprinkler protection, the following actions should be considered.

- Limit the extent and duration of the interruption to a minimum.
- Stop highly hazardous processes.
- Restore protection temporarily by capping open yard mains or sprinkler piping and opening control valve, if possible.

- Provide an emergency water supply to the system by connecting a hydrant, which is in service, with a fire department connection. Where no connection is available, connect to the 2-inch drain. Emergency connections may be charged except during freezing weather. Use this method when the impairment is in the supply system.
- Check availability and condition of other fire protection equipment in the area.
- Post a specially instructed guard in the affected area.
- Make a full flow drain test after repairs have been completed and control valves reopened.

5.14 CLOSING CONTROL VALVES IN EMERGENCY. Under fire conditions, only the fire department officer-in-charge may authorize closing a control valve. This is done only when the fire is out, under control by other means, or there is a sprinkler failure, such as a broken sprinkler main.

Closing a control valve to prevent water damage in case of accidental breakage of piping can be done only if there is no fire. Report valve closing and damage immediately to the person responsible for fire protection. Station responsible personnel at the closed valve with instructions to open it in case of fire.

5.15 DEACTIVATING AUTOMATIC SPRINKLER SYSTEMS. Notify the person responsible for fire protection or the public fire department before deactivating sprinkler systems. Deactivate sprinkler systems as follows:

1. Close the main control valve.
2. Open the drain valves and remove plugs at low points. Drain the system completely. Where low points are not provided with drains (including pendent sprinklers on drops) or piping is not properly pitched, disconnect, drain, and reconnect, providing the proper pitch.
3. Wait 48 hours to allow the condensate to drain. Then remove, drain, and reinstall pendent sprinklers.
4. Where the main control valve is located outside the building, install a 1/2-inch sill cock to bleed off all water in the underground main on the system side of the control valve. Provide a bed of small stones or gravel at the sill cock.
5. Where the main control valve is inside the building and separated from the alarm check valve by a spacer, install a 1/2-inch sill cock on the spacer. Provide protection against freezing from not less than 24 inches above the corporation cock to below the frost line.
6. Where the main control valve is inside the building and directly under the alarm check valve, install a 1/2-inch sill cock on the alarm check valve body below the clapper. Provide protection against freezing.
7. Drain the bodies of check valves on the system side of the main control valve.

8. Close auxiliary drain valves and replace the plugs. Leave sill cocks and 2-inch drain valves open.
9. Where weather conditions are unusually severe, replace inside control valves with post indicator valves, and provide proper drainage.
10. Repair or replace control valve when leakage exceeds capacity of the sill cock.
11. Post signs near the closed valve giving instructions to open the valve in the event of fire. Signs should clearly indicate areas controlled by each valve.
12. Drain off condensate accumulations at low point drains as frequently as conditions require.

5.16 CONVERTING AUTOMATIC SPRINKLER SYSTEMS. When, as a result of an engineering evaluation, it is desired to convert wet pipe automatic sprinkler systems to dry pipe systems, it may be done as follows:

1. Close the main control valve and drain the system.
2. Remove the alarm check valve and its trimmings.
3. Install a dry pipe valve and its trimmings. This may require replacement or recutting of one length of pipe in the riser as the face-to-face dimensions of the two valves may not be the same.
4. Disconnect the fire department pumper connection from the riser, install a blank flange at the riser outlet, and reconnect the pumper connection to the water side of the dry pipe valve.
5. Unless already provided, install a check valve on the supply connection to the sprinkler system.
6. Install a suitable air compressor and connect to the dry pipe valve. An adequate and reliable installed (shop) air supply with enough capacity to restore normal air pressure to the system within 30 minutes may be used instead of a compressor.
7. Check piping from the highest branch line back to the riser. If required, provide additional line pitch as required by NFPA Standard No. 13, "Installation of Sprinkler Systems."
8. Turn pendent sprinklers upright and install upright sprinklers. Where this cannot be done, replace pendent sprinklers with dry pendent sprinklers.
9. Provide low point drains or drum drips at low points.
10. Provide a heated enclosure around the dry pipe valve.
11. Set and maintain the dry pipe valve.

Where, as a result of an engineering evaluation, it is desired to convert dry pipe automatic sprinkler systems to wet pipe systems, do the following:

1. Close the main control valve and drain system.
2. Remove the dry pipe valve and its trimmings.
3. Install an alarm check valve and its trimmings. This may require replacement or recutting of one length of pipe in the riser as the face-to-face dimensions of the two valves may not be the same.

5.17 RESTORING AUTOMATIC SPRINKLER SYSTEM SERVICE. To restore automatic sprinkler service, trace all lines of the sprinkler system from their ends to the main supply connection. Follow these steps:

1. Remove blank flanges or gaskets blocking waterways.
2. Repair or replace cracked fittings or piping.
3. Replace corroded or damaged sprinklers.
4. Repitch improper pitch to piping.
5. Replace or resecure missing or loose hangers.
6. Examine the internal condition of piping at representative points. If accumulations of scale, stones, or other foreign material are found, flush the system thoroughly.
7. Close drain valves and admit water slowly to the system, taking care to avoid damage by water from undiscovered leaks.
8. Make a hydrostatic test of the system if it has been out of service for more than a year, damaged mechanically or by freezing or fire, or extensively repaired, altered, or extended. In this test, maintain a pressure of at least 50 psi higher than normal static pressure, but not less than 150 psi, for 2 hours. For dry pipe systems, make an air pressure test following the hydrostatic test. Maintain 50 psi air pressure for 24 hours. Repair piping if air leakage in excess of 1-1/2 psi occurs. A hydrostatic test of a deluge system requires the temporary replacement of open sprinklers with closed sprinklers. A deluge system should be restored by an experienced contractor.
9. Examine, service, and test alarm check valves, dry pipe valves, quick-opening devices, and alarm devices.
10. Restore the system to full service.

5.18 WATER SUPPLIES FOR SPRINKLER AND STANDPIPE SYSTEMS.

5.18.1 Water Mains. Annual fire flow tests should be conducted to determine the condition of water mains, as follows: (For additional information see NFPA 291, Recommended Practice for Fire Flow Testing and Marking of Fire Hydrants, Chapter 2 and International Fire Service Training Association (IFSTA) Manual, Section 2, Fire Hydrants, to determine the condition of water mains.)

1. Select a hydrant to record pressures (called the residual hydrant).
2. Remove one of the 2-1/2-inch caps and replace it with a 2-1/2-inch cap with 1/4-inch threaded connection for a pressure gauge. Provide a test cock on the connection for blowing off air.
3. Open the hydrant and record the pressure. This pressure is known as the static pressure.
4. Select hydrant(s) for flow measurements.
5. Operate hydrant(s) and measure velocity pressure through flowing outlets by use of Pitot tube and gauge. It is best to pitot the flow from a playpipe connected to a hoseline from the hydrant, rather than the flow discharging directly from the hydrant.
6. With water flowing, record the pressure at residual hydrant. This is known as the residual pressure.
7. Calculate the flow of water from each open orifice from charts or the formula:

$$Q = 29.83 C d^2 \sqrt{p}$$

where: Q = flow in gpm
C = the coefficient of discharge of the orifice
d = the diameter of the outlet in inches
p = the pressure recorded on the pitot gauge in psi

Compare the results of the waterflow test with previous tests to determine if there has been a deterioration. A large drop in the water supply can be attributed to a closed or partially closed valve, or other obstruction in the main.

8. Flush water mains during a capacity test by allowing the flowing hydrant to remain open until the water flows clear.

5.18.2 Fire Hydrants. Check the general condition of hydrants annually including:

1. Check tightness of nozzles, inspecting at a point where nozzles enter hydrant barrel. Caulk when necessary.
2. Check for leaks in the top of the hydrant. If necessary, remove cover and tighten the packing gland, or repack.
3. Check for leaks past gaskets under caps, replace defective gaskets.

4. Check for cracks in barrel. If found, replace the hydrant.
5. Check tightness of valve and seat and watch for lowering of the water level in dry barrel hydrant after the valve is closed. If the level does not drop, listen with your ear against the hydrant. If a noise is heard, the main hydrant valve is probably leaking and must be replaced. If quiet, the drain valve is plugged and must be reopened.
6. Inspect the operating nut and replace it if it has worn or rounded corners.
7. Inspect nozzle threads and replace them if they are damaged.
8. Lubricate the hydrant per the manufacturer's recommendation. Typically, lubrication includes lubricating the operating nut and remove the screw in top of the operating nut and apply lubricant. In addition, lubricate the packing and thrust collar by oiling the joint between the nut and collar.
9. In freezing or subzero weather, check dry barrel hydrants by:

Placing the operating wrench on nut and turning slightly to make sure it is not frozen. If frozen, thaw by using a blow torch on the operating nut.

Remove the hydrant cap and inspect for ice in barrel by lowering a small weight on string. If the hydrant contains ice, thaw by injecting live steam from a portable steam thawer, by using portable heating equipment or by placing a few aluminum chips mixed with twice the amount of caustic soda chips in the hydrant barrel and pour in about 1 cup of water. The heat generated should thaw out hydrant barrel within one-half hour. Remove hydrant nozzle caps to help generated gas to escape.

After the ice is thawed enough to allow opening the hydrant, flush slowly until all ice is melted. If hydrant barrel does not drain after valve is reclosed, pump out all water and fill with salt to prevent the freezing of any water which may accumulate in the barrel.

5.18.3 Fire Department Connections. Check fire department connections annually to be sure:

- Connections are accessible and properly supported.
- Caps are properly secured.
- Hose threads are in good condition.
- Automatic ball drips are clean and move freely.

5.18.4 Water Tanks.

5.18.4.1 Steel Gravity and Suction Tanks. Inspect steel gravity and suction tanks as follows:

1. Check water level monthly and keep tank filled to within a few inches of overflow. When filling, fill the tank until water discharges from the overflow pipe.
2. Check general condition annually and examine the tank for loose scale and leaky seams or rivets.
3. Inspect ladders annually, checking for missing connecting bolts, deteriorated lugs and rungs, and any other conditions that would make the ladders unsafe.
4. Check condition of the roof annually to see that screens on overflow and other openings are in place and are adequate to keep out birds and other animals or debris. Keep the roof hatch covered and the door at the top of the frost proof casing fastened to prevent wind damage, keep out birds, and conserve heat in the winter.
5. Examine sway bracing annually to check for tautness. Tighten turn-buckles if necessary. Look for corrosion under clevis pins and rod loops because the underside is likely to be in worse condition than the top.
6. Inspect condition of paint annually to make sure paint is adequate to protect tank and substructure from corrosion both inside and outside.
7. Inspect tower columns and pits annually to keep the base of tower columns and any pits free from dirt, rubbish, or combustible material. Keep the whole site clear of weeds, brush, or long grass. Keep the tops of foundation piers at least 6 inches above ground level, and the bases of columns in which water may accumulate filled with concrete, sloped and flashed to shed water.

5.18.4.2 Wooden Water Storage Tanks. Inspect wooden water tanks as follows:

1. Check water level monthly and keep the tank full.
2. Inspect the tank annually for leaks. Repair leaks immediately because wood around leaks deteriorates rapidly. Examine steel hoops and bands for corrosion and replace noticeably corroded bands, particularly those corroded at the threaded ends. Check all timber support structures and substructures for splitting, checking, warping, bowing, or curvature and replace or properly support members. Inspect lower ends of timber support members for termite activity. Make sure sway bracing and all bolted connections are tight.
3. Examine tank accessories annually. Examine ladders, opening covers, gauges, screens, and roof for signs of deterioration and repair as necessary.

4. Examine paint annually. Painting does not materially lengthen the life of a wooden tank and is usually done only for aesthetic purposes. Check paint on metal parts to insure that it is adequate to protect parts from corrosion. Repaint if necessary.

5.18.4.3 Concrete Water Storage Tanks. Inspect concrete water storage tanks as follows:

1. Check water level monthly and keep the tank full.
2. Check the general condition annually, inspecting concrete water storage tanks each spring for watertightness and structural condition. Check all interior and exterior surfaces for spalling resulting from frost, for exposed reinforcement, and for other structural deterioration. Remove all loose, scaly, or crumbling concrete. Patch with rich cement grout after wetting concrete and painting with portland cement slurry.
3. Check leakage annually, marking places on the tank's exterior where leakage or seepage occurs. When tank is empty, inspect the interior to locate cracks, porous concrete, breaks in interior seal membrane, or other points where water is escaping. Repair as needed.

5.18.4.4 Rubberized Fabric Embankment Supported Water Tanks. Inspect rubberized fabric embankment supported water tanks as follows:

1. Check water level monthly and keep the tank filled.
2. Each year check the drain outlet around the base of tank to detect any leaks which may not be visible. Check embankment for any erosion and fill as needed. Check fabric for wear and tear. Check for puddles of water on the tank and remove if found. Check the sump area at tank bottom and remove any solids or sediment.
3. Inspect the exterior surface annually for areas of oxidation or weather checking of outer protective paint; repaint as necessary.

5.18.4.5 Pressure Tanks. Inspect pressure tanks as follows:

1. Check water level and air pressure monthly and fill the tank to the required levels, if necessary.
2. Inspect condition of paint annually. The interior of the pressure tank should be inspected by a qualified pressure-vessel inspector to determine if corrosion is taking place and whether painting or repairing is required at three-year intervals.

5.18.4.6 Heating Systems for Water Tanks. Inspect heating systems for water tanks as follows:

1. Check heating systems 2 months before freezing season. Inspect insulation and frost proof casing around the riser. Seal all openings to prevent excessive heat loss. Inspect heating elements to insure proper functioning through the winter season. Clean with a wire brush and paint all pipe and equipment showing exterior corrosion.

2. Operate the heating system 1 month before freezing season. Run the system at least 8 hours to check condition of the heating element,
3. During freezing weather, check heating systems daily.

5.18.4.7 Cathodic Protection Equipment. Inspect cathodic protection equipment as follows:

1. While equipment is operating, note and record current flow shown by meters. If there is no current, check for blown fuses, anodes touching the tank, ground-wire connection to tank, or anodes not immersed in the water. If equipment operates at voltages or amperages over those listed on the name plate, the rectifier may be damaged. Check polarity and direction of current flow. (If connections to rectifier are reversed, rapid damage to tank occurs.) Positive should be connected to anodes and negative to tank for correct polarity.
2. If possible, visually check condition of anodes which deteriorate because of action of current passing from anodes to water. Replace worn anodes. (Watch for diminishing current flow on operating logs which is a sign that the anodes may be failing.)
3. Protect electrodes from ice. If ice formation is a serious problem, turn off current and remove and store the electrodes during the freezing season. The corrosion rate goes down with temperature. Reinstall the electrodes at the end of freezing season.
4. for cathodic protection, see appropriate military service documents,

5.18.5 Fire Pumps.

5.18.5.1 General Inspection. Fire pump units should be maintained in constant readiness. The pump must be able to be started at a moment's notice and be able to run for long periods of time. To insure that these conditions are met, frequent testing is mandatory.

Start engine driven fire pumps weekly and electric driven fire pumps, monthly, allowing them to run at full speed while discharging water through a convenient outlet. Automatically start the pump by dropping system pressure or closing remote start contacts. Inspect the temperature and tightness of the packing glands with each test. During operation, it is important to allow a small amount of water to leak through the packing glands for lubrication and cooling. Check and record the reading of the suction and discharge pressure gauges .

- Check internal combustion engine drivers to insure that the engine is clean and dry. Check the fuel tank and maintain at least an 8-hour fuel supply. Check the quality and quantity of the crankcase oil and renew it if it becomes foul or loses viscosity. Examine the oil filter and replace when necessary. Verify that the battery charger is operating correctly and check the condition of the battery electrolyte. Run the engine for at least 30 minutes. Test the operation of the speed governor and overspeed trip.

- Check the steam turbine drivers by checking the steam trap for removing condensed steam at the throttle. Test the operation of the speed and pressure governors, the overspeed trip, and the steam relief valve.

5.18.5.2 Performance Testing. The condition of fire pumps is determined annually by full operating tests which discharge water from the pump at various flow rates.

- At each flow, record suction and discharge pressures, rates of flow and speed of the pump. To obtain the net pressure available from the fire pump, subtract the suction pressure from the discharge pressure. The rate of flow and the net pressure must be corrected to the rated speed of the pump, if the actual speed (rpm) during testing differs from the rated speed.

The rate of flow is directly proportional to the speed and pressure is proportional to the square of the speed respectively, as follows:

$$\text{gpm } 1 / \text{gpm } 2 = \text{rpm } 1 / \text{rpm } 2$$

$$\text{psi } 1 / \text{psi } 2 = (\text{rpm } 1 / \text{rpm } 2)^2$$

After the flow and pressure have been adjusted, these points should be plotted on graph paper against the standard curve for fire pumps (i.e., pressure at 120% of rated for centrifugal or 140% of rated for vertical pumps at 0% flow; pressure at 100% of rated at 100% flow; and pressure at 65% of rated at 150% flow). Compare the plotted test results with previous pump tests.

If the "plotted" pressure is less than 95% of standard pressure at 100% flow or less than 40% of standard pressure at 150% flow, the pump should be repaired immediately.

If the speed of the pump differs by more than 10% from rated speed, the driver should be repaired immediately.

- To check hose and hose header, close discharge valves from fire pump to the fire protection system. Open the valve to the hose header. Use various combinations of hoses and nozzles (1-3/4- and 1-1/8-inch discharge orifices) to obtain at least six representative flow rates from 0% to at least 150% rated flow.
- To check meter arrangement, close discharge valves from fire pump to fire protection system. Open the valve to inlet side of testing device completely. Adjust the valve downstream of testing device to obtain flow rates of at least six representative points from 0% to at least 150% of rated flow.
- Test controllers according to manufacturer's instructions.

TABLE 5-4
FIRE PUMP TROUBLES AND CAUSES

	Number	Causes	Fire-pump troubles									Number
			Dis-charge pressure too low for gpm discharge	Insufficient water discharge	Pump loses suction after starting	Dis-charge pressure not constant for same gpm	Too much power required	Pump is noisy or vibrates	No water discharge	Pump unit will not start	Pump or driver overheats	
Suction	1	Suction lift too high.....	X	X	X	X		X	X			1
	2	Foot valve too small, partially obstructed, or of inferior design causing excessive suction-head loss.....	X	X	X	X		X				2
	3	Air drawn into suction connection through insufficiently submerged foot valve.....	X	X	X	X		X				3
	4	Air drawn into suction connection through leak.....	X	X	X	X			X			4
	5	Suction connection obstructed.....	X	X	X				X			5
	6	Air pocket in suction pipe.....	X	X	X				X			6
	7	Hydraulic cavitation from too high suction lift.....	X	X				X				7
	8	Well collapsed or serious misalignment.....					X	X		X	X	8
Pump	9	Stuffing box too tight or packing improperly installed, worn, defective, too tight, or incorrect type.....	X			X	X	X		X	X	9
	10	Water seal or pipe to seal obstructed.....	X	X	X	X					X	10
	11	Air leak into pump through stuffing boxes.....	X	X	X	X					X	11
	12	Impeller obstructed.....	X	X			X	X	X			12
	13	Wearing rings worn.....	X	X			X	X			X	13
	14	Impeller damaged.....	X	X				X				14
	15	Wrong-diameter impeller.....	X	X			X				X	15
	16	Actual net head lower than rated.....	X	X								16
	17	Casing gasket defective, permitting internal leakage (multistage pumps only).....	X	X			X					17
	18	Pressure gage on top of pump casing.....	X									18
	19	Incorrect impeller adjustment (vertical-shaft pumps only).....		X			X			X	X	19
	20	Impellers locked.....								X		20
	21	Pump frozen.....								X		21
	22	Pump shaft or shaft sleeve scored, bent, or worn.....					X	X			X	22
	23	Pump not primed.....							X			23
	24	Seal ring improperly located in stuffing box, preventing water from entering space to form seal.....			X						X	24
Pump and/or driver	25	Excess bearing friction due to lack of lubrication, wear, dirt, rusting, failure, or improper installation.....					X	X		X	X	25
	26	Rotating element binds against stationary element.....					X	X			X	26
	27	Pump and driver misaligned. Shaft running off center because of worn bearings or misalignment.....					X	X			X	27
	28	Foundation not rigid.....					X	X			X	28
	29	Engine cooling system obstructed. Heat exchanger or cooling-water system too small. Cooling pump faulty.....									X	29
Driver	30	Driver does not start.....								X		30
	31	Lack of lubrication.....					X	X		X	X	31
	32	Speed too low.....	X	X								32
	33	Wrong direction of rotation.....	X	X			X				X	33
	34	Speed too high.....					X				X	34
	35	Rated motor voltage different from line voltage, e.g. 220- or 440-volt motor on 208- or 416-volt line.....	X	X			X				X	35
	36	Faulty electric circuit, obstructed fuel system, obstructed steam pipe, or dead battery.....								X		36

Talbe 5-4 identifies the most common pump troubles and their possible causes. Additional troubleshooting information for fire pump troubles follows:

1. Suction lift too high. Suction lift should not exceed 15 feet for a horizontal-shaft pump. If vertical distance from the pump center line to the water level, plus friction loss in suction pipe, is over 15 feet, rearrange the suction supply. Check suction connection.
2. Foot valve too small, partially obstructed, or of inferior design. This causes excessive suction-head loss. Replace it with an approved foot valve of proper size or remove obstructions.
3. Air drawn into suction connection through insufficiently submerged foot valve. Lower foot valve,
4. Air drawn into suction connection through leak. This causes the pump to lose suction or to fail to maintain its discharge pressure. Uncover the suction pipe, locate and repair leak(s).
5. Suction connection obstructed. Examine suction intake, screen, foot valve, and suction pipe, and remove the obstruction. Repair or provide screens to prevent a 'recurrence.
6. Air pocket in suction pipe. Air pockets cause a reduction in delivery and pressure similar to an obstructed pipe. Uncover suction pipe and rearrange to eliminate pocket.
7. Hydraulic cavitation from excessive suction lift. See Item 1.
8. Well collapsed or in serious misalignment. Consult a well-drilling company and the pump manufacturer regarding recommended repairs.
9. Stuffing-box too tight or packing improperly installed, worn, defective, or incorrect type. Loosen gland swing bolts and remove stuffing-box gland halves. Replace packing.
10. Water Seal or pipe to seal obstructed. Loosen gland swing bolt, and remove stuffing-box gland halves, water-seal ring, and packing. Clean the water passage to and in the water-seal ring. Replace water-seal ring, packing gland, and packing, following the manufacturer's instructions.
11. Air leak into pump through stuffing-boxes. See Item 10.
12. Impeller obstructed. Does not show on any one instrument, but pressures fall off rapidly when an attempt is made to draw a large amount of water.

Horizontal-shaft pumps: Remove upper case of pump, and remove obstruction from impeller. Repair or provide screens on the suction intake to prevent a recurrence.

Vertical-shaft pumps: Lift out column pipe, and pump bowls from wet pit or well, and disassemble pump bowl to remove obstruction from impeller.

13. Wearing rings worn. Remove upper case, and insert feeler gauge between case wearing ring and impeller wearing ring. Clearance when new is usually 0.0075 inch; clearances of more than 0.015 inch are usually excessive.
14. Impeller damaged. Make minor repairs or return to manufacturer for replacement. If defect is not too serious, order new impeller and use damaged one until replacement arrives.
15. Wrong-diameter impeller. Replace with impeller of proper diameter.
16. Actual net head lower than rated head. Check impeller diameter and number and pump model number to determine whether correct head curve is being used.
17. Casing gasket defective, permitting internal leakage (multistage pumps only). Replace defective gasket. Check manufacturer's drawing to see whether gasket is required.
18. Pressure gauge on top of pump casing. Place gauge in correct location.
19. Incorrect impeller adjustment (vertical-shaft pump only). Adjust impellers according to manufacturer's instructions.
20. Impellers locked. For vertical-shaft pump: Raise and lower impellers by the top shaft adjusting nut. If this is not successful, follow the manufacturer's instructions. For a horizontal-shaft pump: Remove upper case and locate and eliminate obstruction.
21. Pump Frozen. Provide heat in the pump room. Disassemble pump and remove ice. Examine parts carefully for damage.
22. Pump shaft or shaft sleeve scored, bent, or worn. Replace shaft or shaft sleeve.
23. Pump not primed. If a pump is operated without water in its casing, the wearing rings are likely to seize. The first warning is a change in pitch of the sound of the driver. Shut down the pump. Prime the pump before restarting.

For horizontal-shaft pump: Stop pump and open umbrella cock to determine whether pump and suction pipe are completely filled with water.

For vertical-shaft pump: Check water level to determine whether pump bowls have proper submergence.

24. Seal ring improperly located in stuffing-box, preventing water from entering space to form seal. Loosen gland swing bolt, and remove stuffing-box gland halves, water-seal ring, and packing. Replace, putting seal ring in proper location.
25. Excess bearing friction due to lack of lubrication, wear, dirt, rusting, failure, or improper installation. Remove bearings and clean, lubricate, or replace as necessary.

26. Rotating element binding against stationary element. Check clearances and lubrication. Replace or repair the defective part.
27. Pump and driver misaligned. Shaft running off center because of worn bearings or misalignment. Replace bearings. Align pump and driver according to manufacturer's instructions.
28. Foundation not rigid. Tighten foundation bolts or replace foundation.
29. Engine cooling system obstructed; heat exchanger or cooling-water system two small or cooling pump faulty. Remove thermostats; open bypass around regulator valve and strainer; check regulator-valve operation; check strainer; clean and repair if necessary. Disconnect sections of cooling system to locate and remove possible obstruction. Adjust engine cooling-water circulating-pump belt for proper speed without binding. Lubricate bearings of the pump. If overheating still occurs at loads up to 150% of rated capacity, contact pump or engine manufacturer to determine necessary steps to eliminate overheating.
30. Driver does not start. Check electric motor, internal-combustion engine, or steam turbine to locate reason for failure to start.
31. Lack of lubrication. If parts have seized, replace damaged parts, and provide proper lubrication. If not, stop pump and provide proper lubrication.
32. Speed too low. For electric-motor drive, check whether rated motor speed corresponds to rated speed of pump, whether voltage is correct, and whether starting equipment is operating properly.

Low frequency and low voltage in the electric-power supply prevent a motor from running at rated speed. Low voltage may be due to excessive loads, inadequate feeder capacity, or (with private generating plants) low generator voltage. Generator voltage of private generating plants can be corrected by changing the field excitation. When low voltage is from other causes, it may be necessary to change transformer taps or increase feeder capacity. Low frequency is more likely to occur with a private generating plant and should be corrected at the source. Low speed may occur in older type squirrel-cage motors if fastenings of copper bars to end rings become loose. Weld or braze these joints.

With steam-turbine drive, check that valves in steam-supply pipe are wide open; boiler steam pressure is adequate; steam pressure at turbine is adequate; strainer in the steam-supply pipe is not plugged; steam-supply pipe is of adequate size; condensate is removed from steam-supply pipe, trap, and turbine; turbine nozzles are not plugged; and setting of speed and emergency governor is correct.

With internal-combustion-engine drive, check that setting of speed governor is correct; hand throttle is opened wide; or that there are no mechanical defects such as sticking valves, timing off, or spark plugs fouled. Checking mechanical defects may require the services of a trained mechanic.

33. Wrong direction of rotation. Instances of an impeller turning backward are rare but are clearly recognizable by the extreme deficiency of pump delivery. Wrong direction of rotation may be determined by comparing the direction in which the flexible coupling is turning with the directional arrow on the pump casing.

With polyphase electric-motor drive, two wires must be reversed. With a DC driver, the armature connections must be reversed with respect to the field connections. Where two sources of electric current are available, check the direction of rotation produced by each.

34. Speed too high. Check whether pump and driver rated speed correspond. Replace electric motor with one of correct rated speed. Set governors of variable-speed drivers for correct speed. Frequency at private generating stations may be too high.
35. Rated motor voltage different from line voltage for example, 220- or 440-volt motor on 208- or 416-volt line. Install motor of correct rated voltage or larger size motor.
36. Faulty electric circuit, obstructed fuel system, obstructed steam pipe, or dead battery. Check for break in-wiring, open switch, or open circuit breaker. If circuit breaker in controller trips for no apparent reason, make sure oil is in dashpots in accordance with manufacturer's specifications. Make sure fuel pipe is clear, strainers are clean, and control valves are open in fuel-supply system to internal-combustion engine. Make sure all valves are open and strainer is clean in steam line to turbine.

5.18.6 Sprinkler Control Valves. Sprinkler control valves are a vital part of the sprinkler system and must receive a high level of attention. A closed valve when there is a fire can result in a total loss of the facility being protected.

Sealed valves should be inspected weekly. Locked valves or valves with tamper switches should be inspected monthly. Quarterly, underground and post indicator gate valves should be operated to varify valves are open and in general working order.

During annual preventive maintenance inspections, the following should be performed to check underground and post indicator gate valves.

1. Be sure valves are accessible and protected against damage.
2. Be sure valves are clearly marked for location and the direction to open. For underground valves; this may require painting directional arrows on the pavement or nearby wall.
3. Check that post indicator barrels and targets are properly aligned, intact, and the head bolts are tight. (Wrenches are provided.) Be sure valves are either supervised or sealed open.
4. Be sure road boxes or manhole covers to underground valves are clear of ice, snow, or other debris and that valve pits are clean and dry.
5. Make sure adequate protection against freezing is provided.

6. Open valves to determine valve condition. Completely close the valve and then reopen it, count the number of turns required to close and reopen valve, and compare this number to the manufacturer's literature to assure the valve is wide open.
7. Check and lubricate the packing. If packing leaks, dig up the valve and tighten the packing. If necessary, replace the packing. Open the valve as much as possible and pull the stem shoulder tight against bonnet to prevent excessive leaking during the repacking.
8. Check for a bent operating stem. If the stem is bent, the valve tends to bind during a full operational test. Replace stem by shutting valve tight removing the stuffing-box assembly, and unscrewing the stem from stem operating nut. Insert new stem, reassemble the stuffing-box, and repack the valve.
9. Check and replace missing and badly worn operating nuts.
10. Check and lubricate gears, observing and correcting any undesirable operating conditions, such as difficulty in opening and closing of valve.

5.18.6.1 Above Ground Gate Valves. Maintenance procedures for above-ground gate valves are as follows:

1. Lubricate the packing with a few drops of graphite oil, or grease to eliminate excessive friction between valve stem and packing. stop leakage by tightening the stuffing-box nuts which forces the packing gland tight against the packing.
2. Replace the packing, if necessary. Before repacking, open the valve wide, clean stuffing-box by removing all old packing from inside, and clean and polish the valve stem with fine emery cloth. Insert new packing in the stuffing-box and tamp into place with packing gland; stagger the ring splits. After stuffing-box is filled, place a few drops of oil on the stem, assemble the gland, and tighten.
3. Operate the valve from full open position to full closed and back to full open position to prevent gate valves from sticking. Be sure the valve is either supervised or sealed open.
4. Lubricate the rising stem threads with grease.

5.18.7 Check Valves, Waterflow Meters, and Backflow Preventers.

Inspection of check valves, waterflow meters, and backflow preventers should be conducted quarterly. Inspection and testing of these devices is documented in detail in other military publications, including AFM85-21. Typical procedures for inspection and maintenance are as follows:

5.18.7.1 Single and Double Check Valves. Inspect the disc facing by opening the valve and observing the condition of the facing on swing check valves equipped with rubber or leather seats on disc. If the metal seat ring is scarred, dress it with a fine file and fine emery paper wrapped around a flat tool. Check pin wear on wafer check valves. The clapper must be accurately positioned in the seat to prevent leakage.

5.18.7.2 Waterflow Meters. Clean and inspect waterflow meters for worn parts by examining internally, cleaning, and inspecting for worn parts. Meter registration may be impaired by sediment in the interior or by wear of moving parts through long, constant service. Before freezing weather, inspect housing condition of each meter. Make certain meter is protected from exposure to below freezing temperatures.

5.18.7.3 Reduced Pressure Backflow Preventer. Check for evidence of leakage from the differential relief valve which indicates a need for repair. Follow manufacturer's instruction.

5.18.7.4 Automatic Pressure Regulating and Altitude Valves. Test and grease pilot control by changing the pilot control momentarily to operate the valve. Return the control to the original setting and grease pilot-setting threads. To close an open altitude valve, back off the nut on diaphragm spring-tension setting one or two turns. Return nut to its exact position after inspection.

Disassemble and clean the valve according to manufacturer's instruction. Clean any sediment from the interior of the valve. Check seat and piston rings for worn or damaged seats and rings; replace if necessary.

CHAPTER 5. SELF-STUDY QUESTIONS

Instructions: Select the correct answer(s) for each of the following questions.

- Q5-1 The following adverse conditions do not require the replacement of sprinklers:
- a. Discoloration due to corrosion
 - b. Cracked quartz bulbs
 - c. Deposits of paint
 - d. None of the above
- Q5-2 Outside open sprinklers are tested by:
- a. Removing sprinklers and submitting them to a laboratory for testing
 - b. Gauging the orifice opening
 - c. Conducting a water discharge
 - d. All of the above
- Q5-3 Piping and hangers should be checked for the following adverse conditions and repaired:
- a. Bent piping
 - b. Protection from freezing for wet pipe systems
 - c. Proper drainage
 - d. All of the above
- Q5-4 When evidence of obstructed piping is found, the following may be the cause of the obstructing material:
- a. Highly chlorinated water
 - b. Highly acid, alkaline, or saline water
 - c. Carbonated water
 - d. All of the above
- Q5-5 The following methods are used for flushing obstructions from sprinkler systems:
- a. Hydraulic method
 - b. Chemical method
 - c. Mechanical method
 - d. All of the above
- Q5-6 When using the hydraulic method of flushing sprinkler systems, the following should be flushed first:
- a. Cross mains
 - b. Branch lines
 - c. Riser column
 - d. None of the above

- Q5-7 When conducting 2-inch drain tests at sprinkler system risers, if a rapid drop in pressure occurs when the valve is opened and a slow return to normal is experienced when the valve is closed, this may be indicative of:
- a. A normal condition
 - b. A partially closed valve
 - c. A partially filled reservoir
 - d. A fire pump starting as a result of a water flow
- Q5-8 When a water motor alarm fails to ring during a test, this may be indicative of:
- a. Birds nesting in the gong cover
 - b. An open drain on the retard chamber
 - c. Detachment of shaft couplings on the water motor
 - d. All of the above
- Q5-9 Correct methods for determining where leaks are occurring in dry pipe systems are:
- a. Fill piping with pressurized water and check for leaks
 - b. Fill piping with combustible gas and use a flame at the joints to check for leaks
 - c. Add a strong smelling oil to the air supply and check for odors
 - d. Paint fittings with a soapy water solution and check for bubbles
- Q5-10 The minimum temperature which must be maintained in a dry pipe enclosure is:
- a. 32°F
 - b. 42° F
 - c. 52° F
 - d. 62° F
- Q5-11 Dry pipe valves should be trip tested:
- a. Annually
 - b. Semiannually
 - c. Quarterly
 - d. Every other year
- Q5-12 When resetting dry pipe valves, the main control valve should be open.
- a. True
 - b. False
- Q5-13 The air supply valves from manually operated compressors to dry pipe systems should be open at all times.
- a. True
 - b. False
- Q5-14 Nonfreeze systems do not require testing other than a specific gravity test of the nonfreeze solution.
- a. True
 - b. False

Q5-15 To test heat responsive devices on deluge or pre-action systems, use:

- a. A torch
- b. A container of hot water
- c. An electric test set
- d. A cigarette

Q5-16 Precautions to be taken during an impairment include:

- a. Stop hazardous processes
- b. Posting of a fire watch
- c. Provide an emergency water supply
- d. All of the above

Q5-17 To convert a wet pipe sprinkler system to a dry pipe sprinkler system, only the replacement of the alarm check valve with a dry pipe valve is needed.

- a. True
- b. False

Q5-18 A hydrostatic test is performed prior to restoring a deactivated sprinkler system to service when:

- a. The system is a dry pipe sprinkler system
- b. The system has been damaged by fire or freezing
- c. The system has been out of service for more than 1 year
- d. The system has been extensively repaired, altered or extended

Q5-19 To determine if a post indicator valve is open, the target should be checked to see that it reads "open."

- a. True
- b. False

Q5-20 The purpose of operating an above-ground gate valve is to:

- a. Prevent the valve from sticking
- b. Give maintenance personnel exercise
- c. Insure the valve stem is of sufficient length
- d. None of the above

Q5-21 Check valves do not require maintenance.

- a. True
- b. False

Q5-22 Registers in water meters may be impaired by:

- a. Wear on moving parts through long, constant service
- b. Inactivity for long periods of time
- c. Chemicals in the water supply
- d. Sedimentation in the meter interior

Q5-23 Waterflow tests are performed by:

- a. Using one hydrant
- b. Using two or more hydrants
- c. Using no hydrants and calculating the supply by formula based on pressure
- d. None of the above

Q5-24 Methods to thaw frozen fire hydrants include:

- a. Using portable heaters
- b. Injecting live steam into the hydrant
- c. Placing aluminum chips and caustic soda in the hydrant barrel and adding 1 cup of water
- d. All of the above

Q5-25 When filling a suction or gravity tank, water should not be allowed to flow out of the overflow pipe.

- a. True
- b. False

Q5-26 The purpose for keeping the roof hatch covered on gravity tanks is to:

- a. Prevent wind damage
- b. Prevent stagnation of water
- c. Keep out birds
- d. Conserve heat in winter

Q5-27 When examining gravity tank sway bracing for corrosion, the most likely place to find corrosion is:

- a. At turn buckles
- b. On rods
- c. Under clevis pins and rod loops
- d. On top of clevis pins and rod loops

Q5-28 Concrete tanks which are experiencing seepage must be repaired from the inside when the tank is empty.

- a. True
- b. False

Q5-29 Fabric tanks require periodic painting.

- a. True
- b. False

Q5-30 Heating systems for water tanks should be operated before freezing weather occurs.

- a. True
- b. False

Q5-31 An indication that cathodic protection electrodes are deteriorating is:

- a. A high current flow on an ammeter
- b. A pulsing of current flow on an ammeter
- c. A low current flow on an ammeter
- d. No current flow on an ammeter

Q5-32 Engine driven fire pumps should be started weekly and run at:

- a. Full speed for 30 minutes
- b. One-half full speed for 30 minutes
- c. Full speed for 15 minutes
- d. One-half full speed for 1 hour

Q5-33 The minimum fuel supply duration for an engine driven tire pump is:

- a. 4 hours
- b. 8 hours
- c. 12 hours
- d. 24 hours

Q5-34 A standard fire pump is capable of producing 100% of rated flow at 100% of rated pressure (head) and 150% of rated flow at of rated head.

- a. 50%
- b. 65%
- c. 100%
- d. 150%

CHAPTER 6. FOAM EXTINGUISHING SYSTEMS

6.1 GENERAL. Firefighting foam was first introduced in the late 1800s for the protection of coal mines. This foam was known as chemical foam because the foam bubbles were produced by a chemical reaction. The chemical foams are now obsolete and have been replaced by mechanical or air foam. The foam bubbles in mechanical foam are produced by introduction of air into special foam-water solutions.

Foam extinguishes fire in four ways:

- By smothering the fire and preventing air from mixing with flammable vapors.
- By suppressing flammable vapors and preventing their release.
- By separating flames from the fuel surface.
- By cooling the fuel and adjacent hot objects to prevent reignition.

Quality foam must:

- Be light enough to flow freely and float on low specific gravity flammable liquids.
- Be strong enough to form a cohesive blanket and resist disruption by wind.
- Resist heat.
- Resist fuel saturation.
- Retain sufficient water to seal against hot surfaces.

The principal uses of foam are:

- Extinguish burning liquids which are lighter than water.
- Prevent ignition and fire of spills or other hazards by applying foam blankets.
- Insulate and protect exposed surfaces from radiant heat.
- Extinguish fires in ordinary combustible materials such as wood, paper, and rags.

Foams should not be used as an extinguishing agent for the following types of fires:

- Flowing liquid fires, such as tank leaks or pressure leaks, are not readily extinguished by foams alone. Other extinguishing agents, which are compatible with foam, should be used in conjunction with the foam.

- Fires in materials which violently react with water, such as combustible metals (sodium, phosphorus).
- Energized electrical equipment fires because foam is a conductor of electrical current.

Foam may be classified into two general categories: low expansion foam and high expansion foam. Low expansion foam is foam having an expansion of 100 or less. High expansion foam is foam having an expansion of greater than 100. Expansion is the ratio of volume of foam produced to the volume of solution used to generate the foam. For example, an 8 expansion means 800 gallons of foam are produced from 100 gallons of solution. Whereas foam is not toxic, in a total flooding application visibility can be appreciably reduced, possibly causing entrapment of personnel. Protective equipment should be provided to allow for the rescue of trapped individuals if fire department response is not expected to be prompt.

6.1.1 Protection Considerations. There are two general classes of flammable liquids hydrocarbons and polar solvents. Hydrocarbons are not water miscible (do not mix with water) products, such as crude oil, gasoline, hexane naphtha, and diesel oil. Polar solvents are generally water miscible products such as alcohols esters and ketones. It is necessary to select the proper foam for the specific hazard.

6.1.1.1 Concentrates. Several types of foam liquid concentrates are available for different classes of flammable liquids and storage temperature considerations. Each major type of foam concentrate is also available in modified forms for use in various proportions in the water, generally 3 or 6%. The types of foam concentrate are:

- Regular Protein. Protein foams are manufactured from protein hydrosysate with compounds added for foam stabilization, freezing point suppression, and preservation. Protein foams are for use on hydrocarbon type flammable liquid fires.
- Fluoroprotein. These foams are similar to the regular protein foams except a synthetic fluorocarbon surfactant has been added to improve the foam's firefighting performance. These improvements include:

Increased extinguishing ability.

Increased ability to flow readily, known as "fluidity".

- Dry chemical extinguishing agent compatibility.
- Superior sealability and burnback resistance.
- Improved properties which allow subsurface injection of these foams into hydrocarbon fuel storage tanks.

Drainage.

- Aqueous Film Forming Foam (AFFF). AFFF is a combination of fluorocarbon surfactants and synthetic foaming agents. An aqueous film of foam solution is produced by the action of the fluorocarbon surfactant reducing the surface tension of the foam solution to a

point where the fuel can actually support the foam solution. The aqueous film rapidly spreads across the surface of a hydrocarbon fuel permitting a quick knock-down of the fire. The effectiveness and durability of the aqueous film is directly influenced by the surface tension of the hydrocarbon fuel.

AFFF is most effective on fuels which have high surface tension, such as kerosene, diesel fuel, and jet fuel. They are not as effective on low surface tension fuels like gasoline and hexane. AFFF is designed to drain foam solution slowly from bubble to provide optimum filming for rapid fire extinguishment. Long term sealability and burnback resistance are sacrificed by rapid drainage. Long term stability and burnback resistance can be enhanced by using air aspirating nozzles for making foam.

- Alcohol Type Foam. Flammable liquids of the polar solvent or alcohol type present a special fire protection problem because these fuels are water soluble. Because of this, the fuels are "dissolved" into the water contained in the normal foams to destroy the foam blanket. Alcohol type foams have a special additive which forms an insoluble barrier between the flammable liquid and the foam.

6.2 LOW EXPANSION FOAM SYSTEMS. Fixed-pipe foam extinguishing systems usually employ low expansion foam as the agent.

6.2.1 Proportioning Methods. Foam is produced by blowing air into a solution of water and foam concentrate. This solution is obtained with proportioning equipment. Correct foam liquid proportioning is essential to produce foam of optimum quality. Several methods of proportioning are described below:

6.2.1.1 Line Proportioning. Line proportioning is primarily used for portable equipment but it is also used for some fixed installations. Line proportioners are in the form of a venturi. Water under pressure flowing through the venturi creates a vacuum which inducts foam liquid concentrate into the water stream (Figure 6-1). Line proportioners offer an inexpensive method of proportioning when the water supply pressure is reasonably high. Each proportioner is designed for a specified discharge rate based on a given water pressure. Changes in water pressure cause corresponding changes in discharge quantity and proportioning which requires a change in the venturi. The pressure drop through the venturi section of the line proportioner is approximately one-third of the inlet pressure.

6.2.1.2 Pressure Proportioning. A pressure proportioning system (Figure 6-2) uses a venturi or orifice to create a pressure differential with water flowing through the device. A portion of the water is diverted to the foam liquid storage tank to pressurize it. The water pressure in the tank forces the foam liquid into the low pressure area of the venturi. The differential across the venturi varies in proportion to the volume of water flow, so that one venturi will proportion properly over a wide range of flows. The pressure drop through this unit is relatively low and this method can be used with lower pressure water supplies. During use, water displaces the foam supply in the tank and prevents the foam liquid from being replenished. When the foam concentrate supply is exhausted, the system must be shut off and the water in the foam concentrate tank drained.

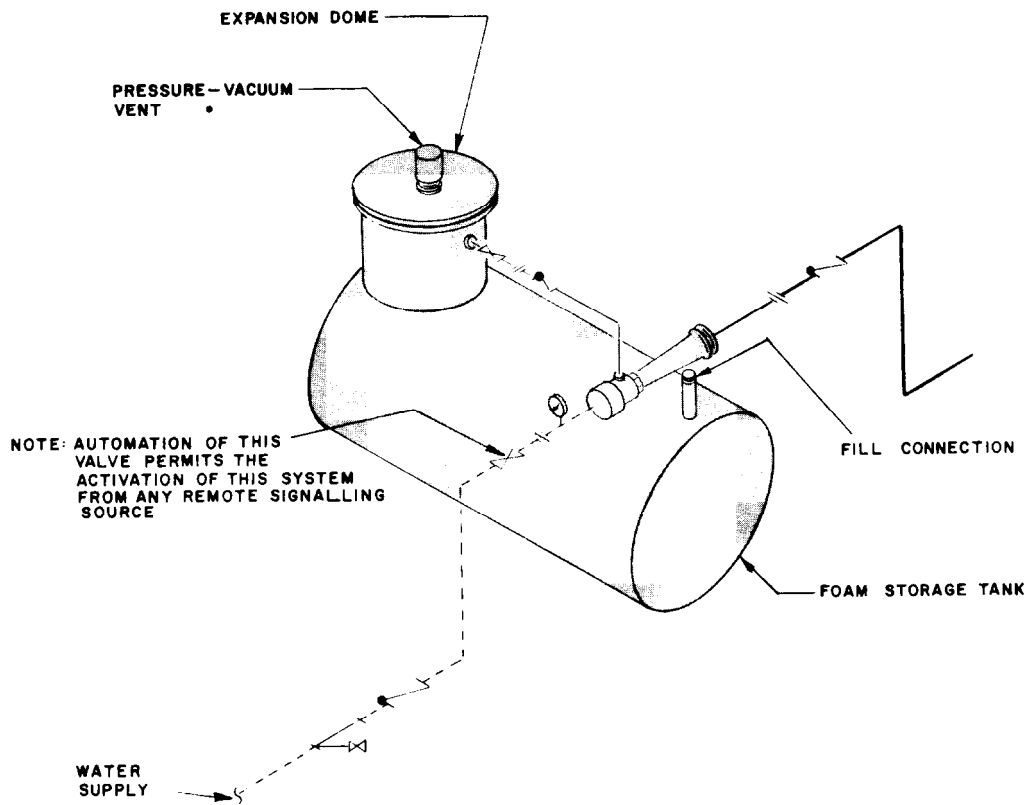


FIGURE 6-1
LINE PROPORTIONER INSTALLATION

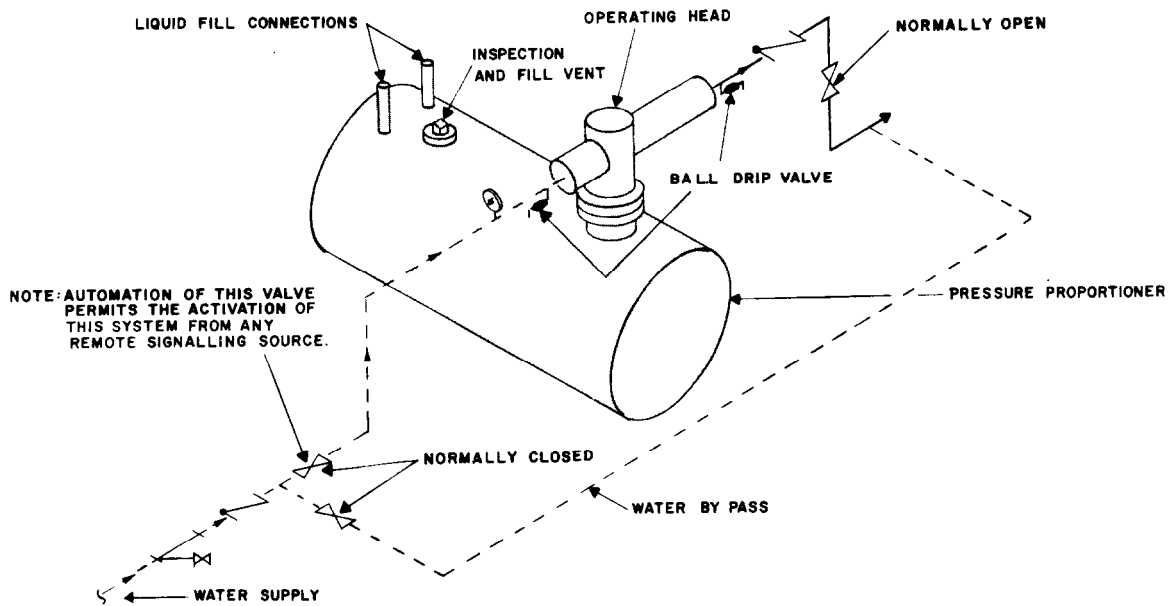


FIGURE 6-2
PRESSURE PROPORTIONER INSTALLATION

6.2.1.3 Pressure Proportioning Tank. This method operates exactly the same as the pressure proportioning system. However, the foam storage tank has a diaphragm. Because of the diaphragm, this type of tank is often referred to as a bladder tank (see Figure 6-3). During operation, water flows into the tank and squeezes out the foam liquid by pressing on the diaphragm.

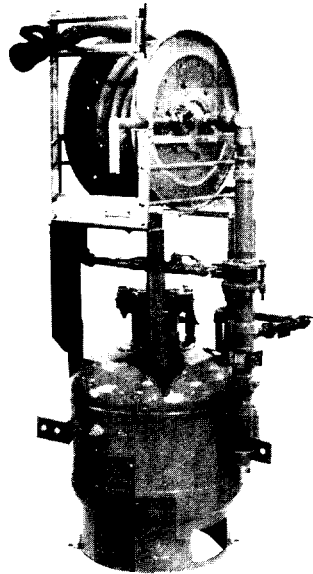
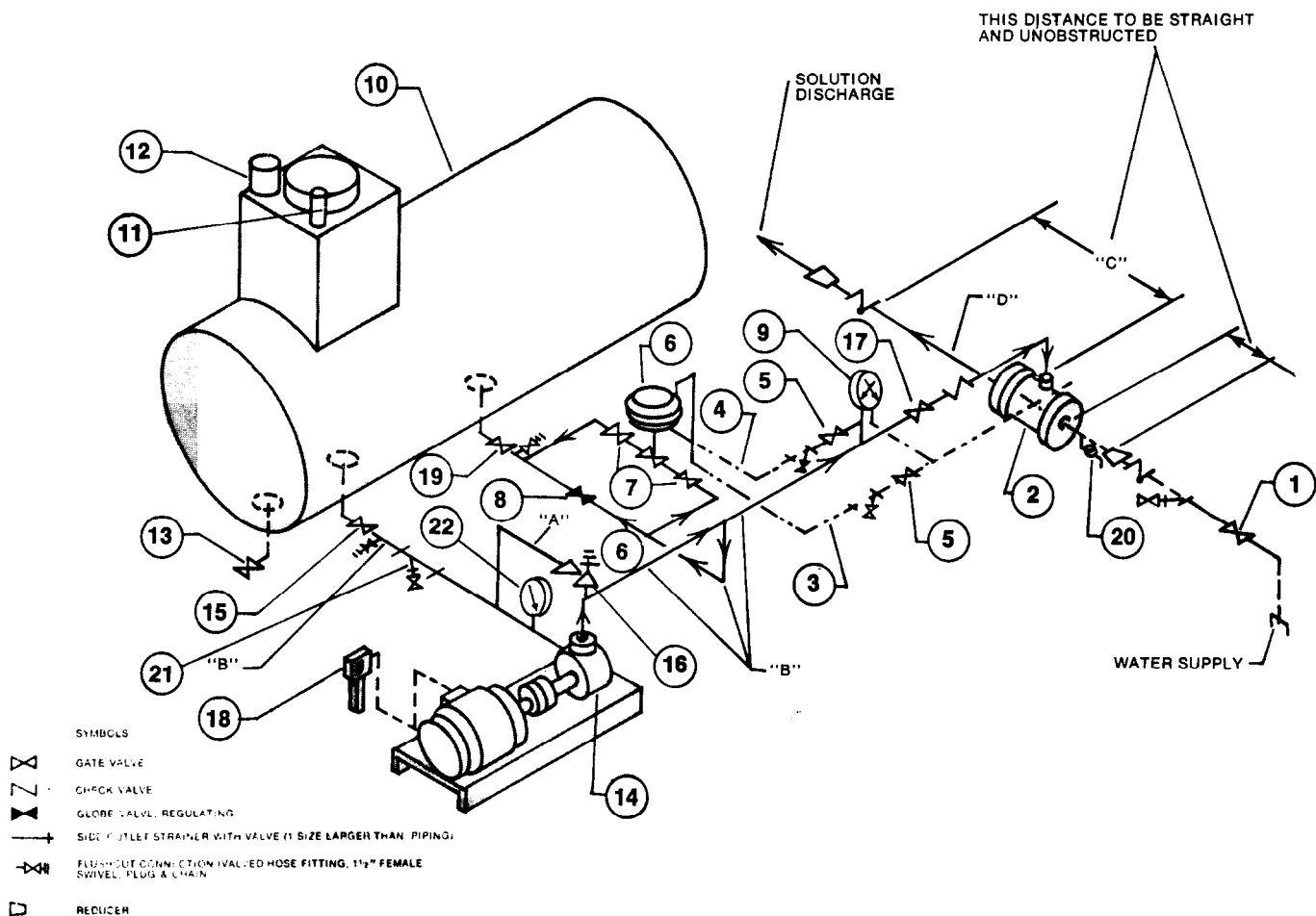


FIGURE 6-3
BLADDER TANK AND HOSE REEL SYSTEM

6.2.1.4 Balanced Pressure Proportioning. This frequently used method is able to automatically proportion foam over a wide range of flow rates. The balanced pressure proportioning system (Figure 6-4) uses two orifices: one for the water supply and the other for the foam supply, which is approximately 3 or 6% of the area of the water supply orifice, depending on the foam concentration to be provided. These orifices discharge into a common low pressure area. To provide correct proportioning, the inlet pressures to the two orifices must be equal. The orifice inlet pressures are governed by a diaphragm valve in the foam liquid piping. This valve is controlled by pressure sensing lines from the upstream side of the water and foam supply orifices. The diaphragm valve automatically adjusts the foam liquid pressure to the water pressure. Gauges are used for manual operation and a valve on the foam liquid bypass line is adjusted to keep the pressures equal.



LEGEND

- | | |
|---|---|
| 1. WATER SUPPLY VALVE (NORMALLY CLOSED). | 13. LIQUID STORAGE TANK DRAIN VALVE (NORMALLY) CLOSED), |
| 2. RATIO-FLOW PROPORTIONER. | 14. FOAM LIQUID-PUMP AND MOTOR, |
| 3. WATER BALANCE LINE. | 15. LIQUID-PUMP SUPPLY VALVE (NORMALLY CLOSED). |
| 4. LIQUID BALANCE LINE. | 16. PRESSURE RELIEF VALVE (SETTING AS REQUIRED BY SYSTEM). |
| 5. BALANCE LINE VALVES (NORMALLY OPEN). | 17. LIQUID-PUMP DISCHARGE VALVE (NORMALLY CLOSED). |
| 6. DIAPHRAGM CONTROL VALVES - AUTOMATIC BY-PASS - MUST BE IN VERTICAL POSITION. | 18. ELECTRIC MOTOR STARTER AND SWITCH, |
| 7. BLOC VALVE (NORMALLY OPEN), | 19. LIQUID RETURN LINE VALVE (NORMALLY CLOSED). |
| 8. REGULATING GLOB VALVE - MANUAL BY-PASS (NORMALLY CLOSED), | 20. BALL DRIP VALVE, 3/4" (INSTALL IN HORIZONTAL POSITION), |
| 9. WATER AND LIQUID PRESSURE GAUGE (DUPLEX), | 21. STRAINER, |
| 10. FOAM LIQUID STORAGE TANK. | 22. COMPOUND GAUGE, |
| 11. LIQUID STORAGE TANK FILL CONNECTIONS, | |
| 12. PRESSURE-VACUUM VENT (MOUNTED ON EXPANSION DOME). | |

FIGURE 6-4
BALANCED PRESSURE PROPORTIONER INSTALLATION .

6.2.1.5 Around-the-Pump-Proportioning. This method has a small line from the discharge of the water pump tied back into the pump suction line. An eductor is placed in the line and is connected to the foam liquid supply (Figure 6-5). This method requires that the gauge pressure on the suction side of the pump be zero or negative (vacuum). The principle of operation is the same as line proportioning.

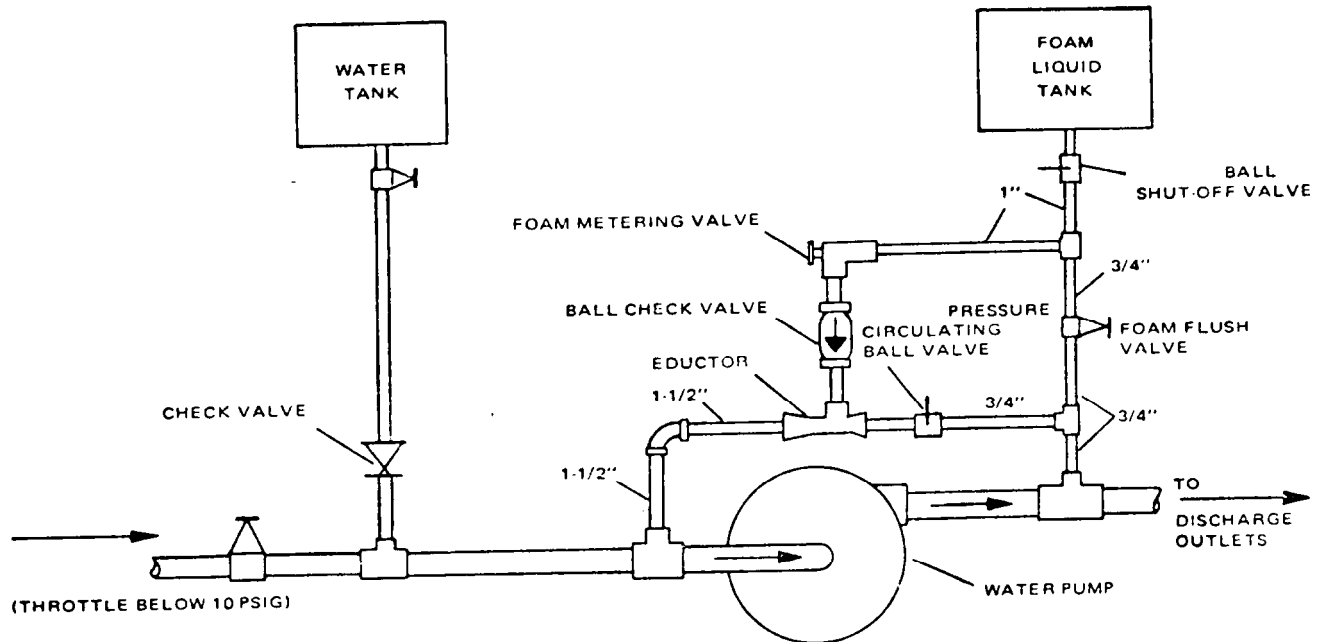


FIGURE 6-5
AROUND-THE-PUMP PROPORTIONER INSTALLATION

6.2.2 Foam Makers. Foam makers convert the solution into foam bubbles.

6.2.2.1 Low Back Pressure Foam Makers. Low back pressure foam makers include foam nozzles, foam chambers, foam/water sprinklers, and other special devices. The foam makers operate by aspiration, causing turbulence. Foam is produced by the contact of the foam/water solution and the turbulent air. Foam expansion depends on the type of foam liquid, design of the foam maker, water quality, water temperature and inlet pressure to the foam maker. Most foam nozzles (Figure 6-6) produce an expansion ratio of 8 to 10 times the solution volume. Foam chambers (Figure 6-7) provide an expansion ratio of 5 to 7. An expansion ratio of 3 to 6 are usually produced by foam water sprinklers (Figure 6-8) or other spray devices.

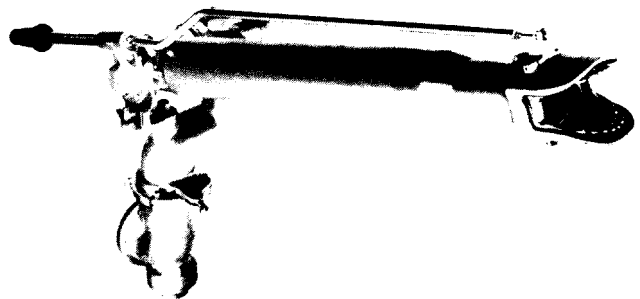
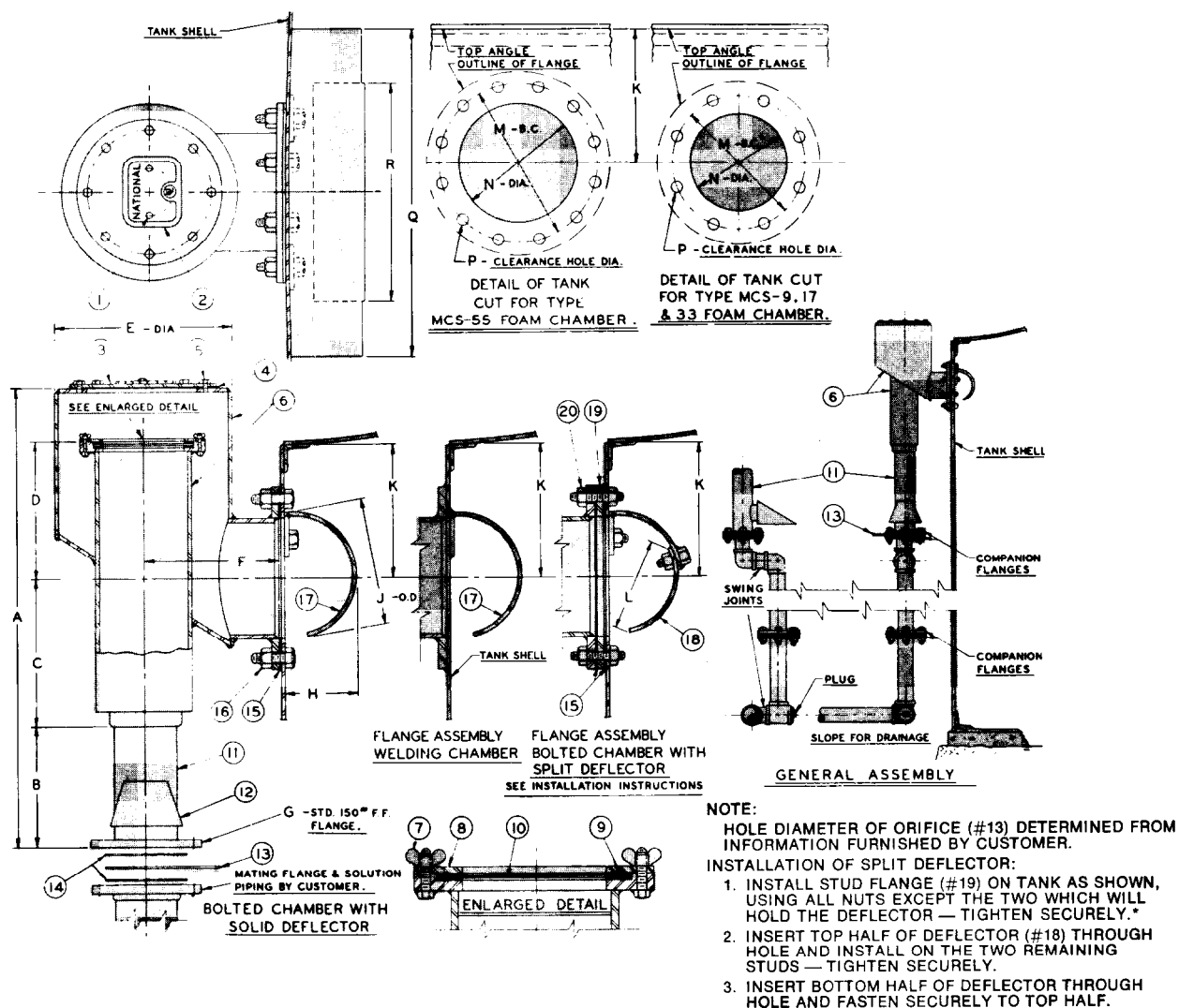


FIGURE 6-6
MONITOR-MOUNTED FOAM NOZZLE



LEGEND

- | | |
|----------------------------|-------------------------------------|
| 1. DRIVE SCREW | BOLTED CHAMBER WITH SOLID DEFLECTOR |
| 2. NAMEPLATE | 15. FLANGE GASKET |
| 3. INSPECTION HATCH | 16. NUT AND BOLT |
| 4. INSPECTION HATCH GASKET | 17. DEFLECTOR (SOLID) |
| 5. CAP SCREW | BOLTED CHAMBER WITH SPLIT DEFLECTOR |
| 6. CHAMBER BODY | 15. FLANGE GASKET |
| 7. WING NUT | 18. DEFLECTOR (SPLIT) |
| 8. DIAPHRAGM RING | 19. STUD FLANGE WITH STUDS |
| 9. CONTAINER CEMENT | 20. HEX NUT |
| 10. DIAPHRAGM | WELDED CHAMBER |
| 11. FOAM MAKER | 17. DEFLECTOR (SOLID) |
| 12. AIR STRAINER | 18. DEFLECTOR (SPLIT) |
| 13. ORIFICE PLATE | |
| 14. RING GASKET | |

FIGURE 6-7
FOAM CHAMBER ASSEMBLY

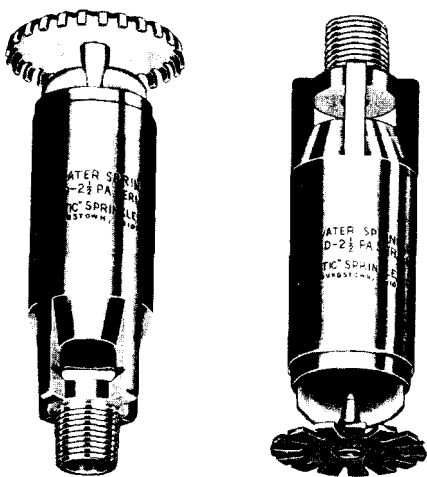


FIGURE 6-8
FOAM WATER SPRINKLERS

6.2.2.2 High Back Pressure Foam Makers. These devices (Figure 6-9) are generally used for subsurface injection of foam into flammable liquid storage tanks. Foam is produced when air is drawn in via the strainer and mixes with the foam concentrate. This application requires that the foam, after being formed, has a residual pressure so that it can be forced against the positive head to the surface of the tank (Figure 6-10). Expansion in these foams is small (approximately two to four times solution volume) to reduce fuel pickup while the foam travels through the fuel to the surface.

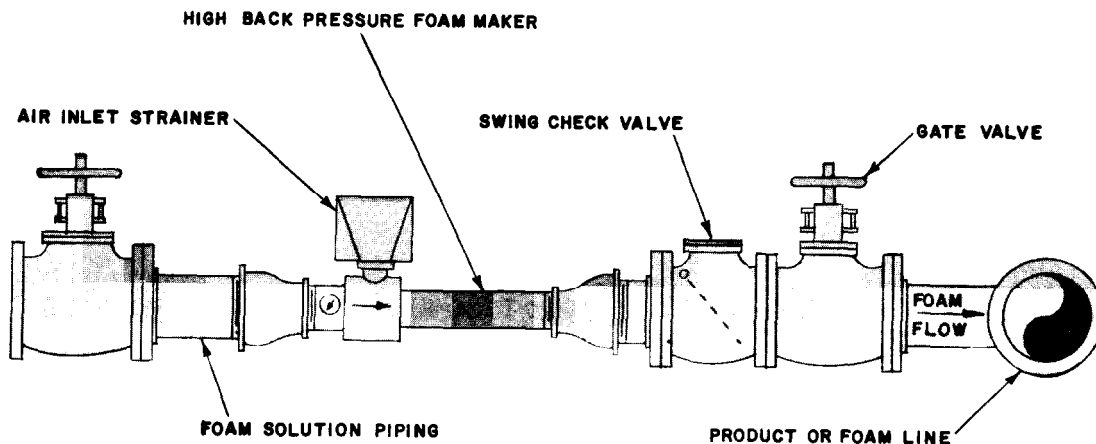


FIGURE 6-9
HIGH BACK PRESSURE FOAM MAKER

6.3 HIGH EXPANSION FOAM SYSTEMS. High expansion foam has an expansion ratio from 1:100 to 1:1000. These foams can transport water to inaccessible locations and produce volumetric displacement of air, vapor, heat, and smoke in fire situations. These systems are used for the control and extinguishment of Class A and Class B fires and as a flooding agent for use in confined areas.

High expansion foam fights fire in the following ways:

- When generated in sufficient volume, the foam prevents air, which is necessary for continued combustion, from reaching the fire.
- When forced into the heat of a fire, the water in the foam is converted to steam, reducing the oxygen concentration by diluting the air.
- Converting water to steam absorbs heat from the burning fuel.

- The relatively low surface tension of the foam solution, which is not converted to steam, penetrates Class A materials.
- When accumulated in depth, the foam provides an insulating barrier to protect exposed materials or structures and prevent fire spread.

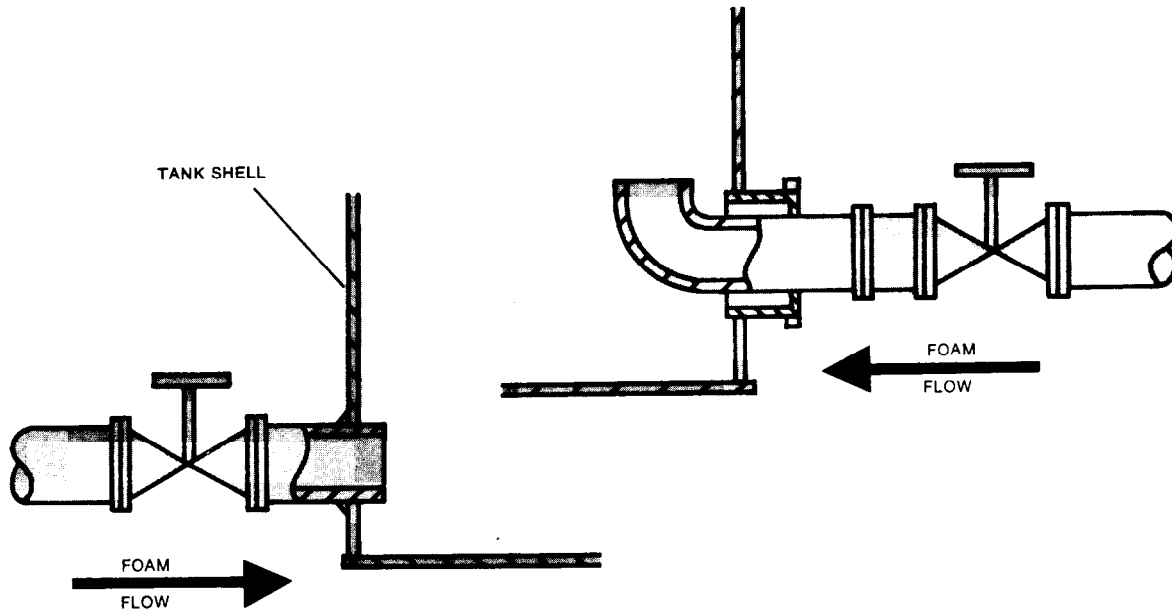


FIGURE 6-10
TYPICAL HIGH BACK PRESSURE FOAM DISCHARGE CONNECTIONS AT TANK

6.3.1 Foam Concentrates. High expansion foam concentrates are different from low expansion foam concentrates; they are not interchangeable. Only high expansion foam concentrates can be used in high expansion foam systems. High expansion foam concentrates are usually proportioned at 1.5%.

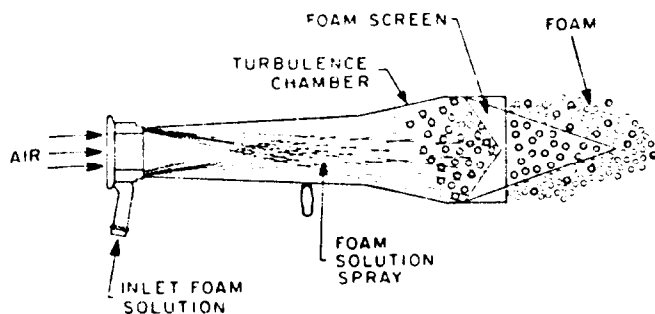
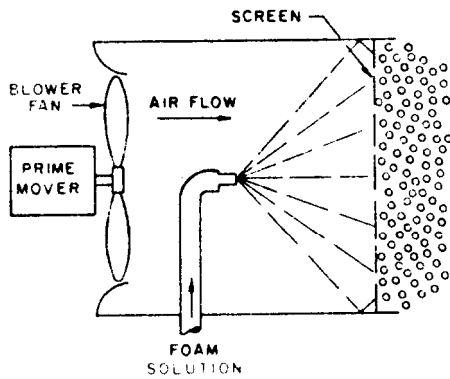


FIGURE 6-11
ASPIRATING TYPE HIGH EXPANSION
FOAM GENERATOR

6.3.2 Foam Generators. There are two types of foam generators for producing high expansion foam:

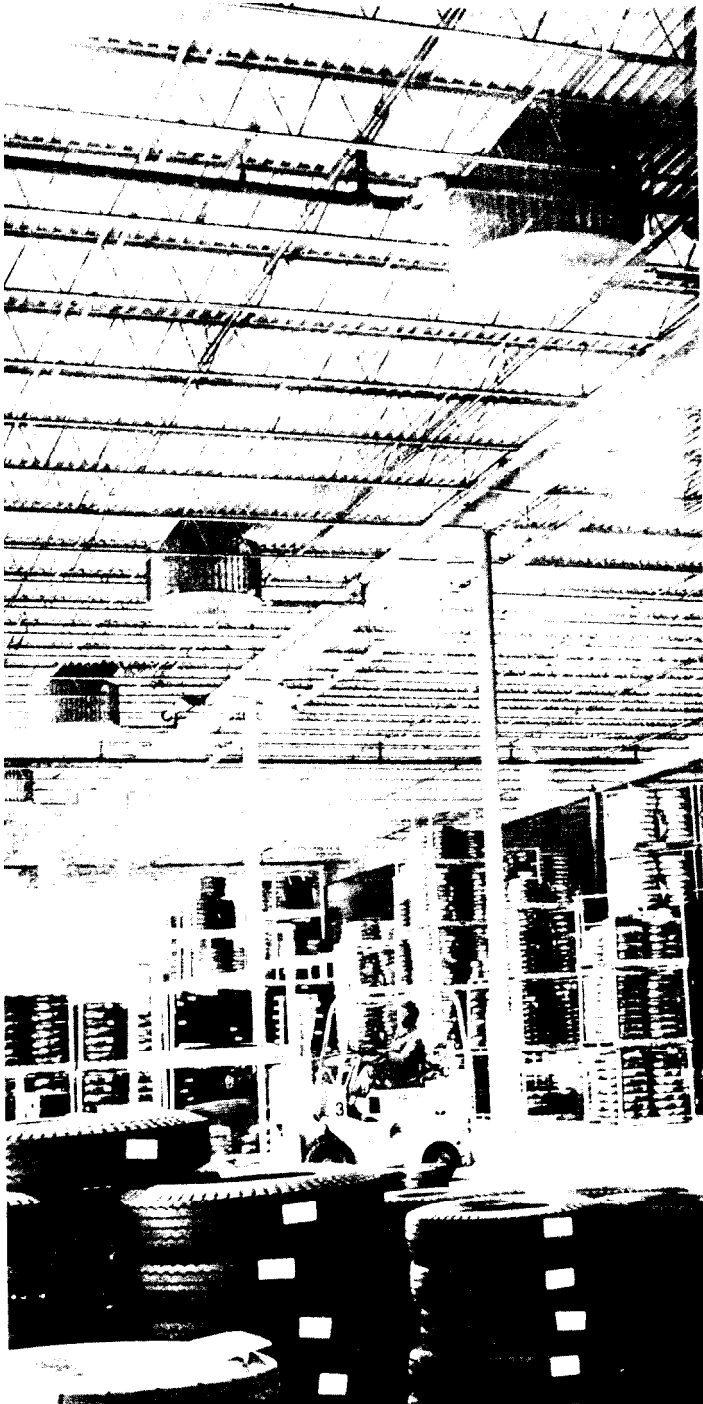
6.3.2.1 Aspirator Type. The aspirator (Figure 6-11) produces foam with expansion ratios of less than 250:1. Jet streams of foam solution entrain the surrounding air. The mixture is then passed through a screen which produces the foam.

6.3.2.2 Blower Type. This type of generator is most common. A fan powered by a water motor or an electric motor blows air through a screen (Figure 6-12). In the case of the water powered unit, the foam solution first passes through the water motor, which powers the fan, and is then discharged onto the screen. The air stream passing through the screen produces the foam. Electric motor driven fans are also used. Water powered generators require a water pressure at the generator



of 70 psi. Electric powered generators require a pressure of 15 psi at the unit.

6.4 ASSOCIATED ALARM SYSTEMS. The alarm systems described in Chapters 2 and 3 can be used to activate foam extinguishing systems. There are some special considerations for alarm systems used in this way.



Fast Response. Foam is used as an extinguishing agent in special hazard situations which require prompt application of the extinguishing agent. The detector response time is an important factor affecting the speed of agent release. Optical type detectors which promptly sense infrared or ultraviolet radiation from a fire are frequently used.

Cross Zoning. Fast acting detectors occasionally cause spurious alarms which may result in the unwanted release of the extinguishing agent. One solution to this tendency is cross zoning. Detectors in an area are divided into two groups and connected as separate zones to the control unit. Actuation of at least one detector from each zone is required before the extinguishing agent is released. If only one detector is actuated, an alarm is caused, but no agent is released. In the case of small fires, this permits use of a portable extinguisher. If response to the alarm is slow and the fire continues to grow, a detector from the second zone is actuated and the extinguishing agent is released.

Explosion Proof Equipment. Electrical alarm equipment located in the hazardous environment must be designed for the application. Usually

FIGURE 6-12

BLOWER TYPE HIGH EXPANSION FOAM GENERATOR

only detectors and associated conduit and junction boxes cannot be located in other, less hazardous, areas. Detectors and junction boxes for the hazardous environment must be explosion proof and the heavy wall, rigid conduit must be used.

6.4.1 Initiating Devices. Initiating devices used with alarm systems for causing agent release are usually electrical, high speed infrared or ultraviolet detectors (discussed in Chapters 2 and 3). Factors affecting detector effectiveness such as electrical power and air pressure, if pertinent, are electrically supervised.

One or two manual methods to activate the foam system are usually provided. An electrical manual initiating device, similar to the noncoded manual devices described in Chapters 2 and 3, may be connected to the alarm system control unit to cause immediate foam discharge regardless of any cross zoning, or it may be electrically connected directly to cause foam release, independent of the alarm system. Manual release usually causes an alarm by actuation of a pressure switch similar to those used to detect sprinkler waterflow, described in Chapter 2. The manual method for foam release may also be a direct mechanical actuation of a control valve, independent of any alarm system.

6.4.2 Circuit Arrangement and Function. The normal circuit arrangement for a building alarm system which causes foam agent release includes an auxiliary alarm output from the control unit which causes electrical actuation of a solenoid operated water control valve or other actuating device. Another auxiliary alarm contact closure or voltage output may be connected to start a pump, if required by the particular foam system. The power supply for detectors may be the main power supply for the building alarm system or an independent supply of a similar type.

6.4.3 Alerting Devices. Alerting devices should be provided outside of an area protected with a total flooding system, warning people that the system has been discharged. The alerting means may consist of a visual indication. A warning sign should also be included to discourage unauthorized personnel from entering the room until the agent is removed.

CHAPTER 6. SELF-STUDY QUESTIONS

Instructions: Select the correct answer(s) for each of the following questions.

Q6-1 Mechanical foam is produced by:

- a. Mixing water with air foam concentrate
- b. Mixing chemical foam concentrates and heating
Introducing air into foam-water solutions
- c. Introducing electric current into foam concentrate

Q6-2 Firefighting foams are generally used for the following types of fires:

- a. Flammable liquids
- c. Electrical equipment
- b. Ordinary combustibles
- d. All of the above

Q6-3 The two most common proportioning rates for low expansion foam are:

- a. 2%
- b. 3%
- c. 5%
- d. 6%
- e. 9%

Q6-4 Foam concentrates may be interchanged when used for specific hazards.

- a. True
- b. False

Q6-5 Aqueous film forming foam (AFFF) is most effective on fires of:

- a. Electrical equipment
- c. Hexane
- b. Gasoline
- d. Kerosene

Q6-6 The most common type of proportioning used for automatic proportioning over a wide range of flow rates is:

- a. Line proportioning
- c. Balanced pressure proportioning
- b. Pressure proportioning
- d. Around-the-pump proportioning

Q6-7 The amount of foam expansion depends on:

- a. The type of foam liquid
- b. The foam maker
- c. Water quality, temperature, and pressure
- d. All of the above

Q6-8 High expansion foam can be produced by injecting fluoroprotein foam concentrate into a high expansion foam generator.

- a. True
- b. False

CHAPTER 7. INSPECTION, TESTING, AND MAINTENANCE OF FOAM SYSTEMS

Inspect all systems annually to ensure that they are in full operating condition. Regular service contracts with the manufacturer or installer are recommended. Recommended inspection and test frequencies for foam systems are summarized in Table 7-1.

TABLE 7-1
SUMMARY OF INSPECTION AND TEST FREQUENCIES FOR FOAM SYSTEMS

Item	Monthly	Quarterly	Annually	Every 3 Yr
1. Check foam concentrate level in tank ^a	x			
2. Inspect foam concentrate storage containers for corrosion		x		
3. Check foam concentrate quality			x	
4. Insure all valves are in correct position	x			
5. Check water supply pressures	x			
6. Inspect foam system piping			x	
7. Visually inspect proportioning devices, pumps, and foam makers	x			
8. Operate pumps and all systems without producing foam		x		
9. Insure all interlocks and closures operate correctly		x		
10. Operate foam pumps and all systems with foam discharge				x

^aFor supervised systems inspection can be performed annually or during routine facility inspections, whichever is more frequent.

7.1 LOW EXPANSION FOAM SYSTEMS. Inspect and test components of low expansion foam systems as follows:

- Foam-Producing Equipment. Visually inspect for physical damage to proportioning devices, their accessory equipment, hose, and foam makers monthly. In addition, check to see that foam makers are oriented in proper position and direction as required for effective operation (especially turret and oscillating nozzles) .
- Concentrates. Check concentrate level in tanks monthly. Inspect foam concentrates and their tanks or storage containers quarterly for evidence of excessive sludging or deterioration. Submit samples of concentrate to the manufacturer or qualified laboratory to test and ascertain foam quality.
- Discharge. Operate all systems and allow some foam to be discharged, every 3 years. A laboratory type field test of foam should be performed annually to check the physical characteristics of the foam as delivered (see section 7.3). Contact a qualified manufacturer or installer for this service.
- Strainers. Inspect and clean strainers after any discharge of foam, whether for a test or a fire.
- Valves. Monthly insure all valves in foam system are in correct position.
- Water Supply. Check water supply pressure monthly,
- Pumps . Operate pumps and all systems, without producing foam, quarterly.
- Piping. Examine aboveground piping to determine its condition and that proper drainage pitch is maintained. Make pressure tests of normally dry piping when visual inspection indicates questionable strength due to corrosion or mechanical damage. Spot check underground piping for deterioration at least every 5 years (see Chapter 5).

7.2 HIGH EXPANSION FOAM SYSTEMS. High expansion foam systems should be tested and maintained as follows:

- Foam-Producing Equipment. Visually inspect all foam concentrate pumps, tanks, lines, and proportioners for damage or leaks monthly. Check and inspect all high expansion foam systems annually for proper operation.
- Concentrates. Check foam concentrate level in tanks monthly. Any changes in the foam concentrate which indicate deterioration in quality should be checked annually. A laboratory analysis of foam quality should be performed annually by the manufacturer or qualified laboratory.
- Discharge. Perform a discharge test every 3 years or when any inspection indicates the need for such a test, i.e. reduced water

supply pressure. As a part of the discharge test, distribution patterns of the foam should be observed and compared to that from previous tests.

- Strainers. Inspect and clean strainers after any discharge of foam, whether for a test or a fire.
- Valves. Insure all valves in foam system are in correct position monthly.
- Water Supply. Check water supply pressure monthly.
- Interlocks. Insure all interlocks and closures to protected area operate correctly, quarterly.
- Pump s . Operate all concentrate pumps, without discharging foam, quarterly.

7.3 FOAM QUALITY. The foam concentrate, foam solution and foam should be sampled on an annual basis to check for any changes in quality which would alter the effectiveness of the foam. Changes in quality may result from degradation due to aging, contamination or other effects. The details of the complete sampling and testing procedure are included in NFPA 11, Standard for Low Expansion Foam and Combined Agent Systems, and NFPA 412, Standard for Evaluating Foam Fire Fighting Equipment on Aircraft Rescue and Fire Fighting Vehicles.

7.3.1 Foam Concentrate. Foam concentrate quality deterioration can be observed by characteristics such as excessive sludging, a yellow tint, and an especially foul odor. Attention should be given to the "shelf life" of the foam concentrate.

7.3.2 Foam Solution. Foam solutions can be checked for proper proportioning. The purpose of these tests are to check the proportioning equipment and to detect any presence of contaminants. The test can be performed by field personnel, though laboratory personnel may be contacted to observe and supervise or to completely conduct the test.

A comprehensive description of the test is included in NFPA 11 and NFPA 412. The refractive index of the solution is used as a means of measuring the proportion of foam concentrate. However, variations in water quality and differences in foam concentrates from one manufacturer to another can significantly "affect the refractive index of foam solutions. Annually, a calibration curve should be constructed of foam concentrate proportion versus refractive index since water quality and foam concentrate properties can change with time.

A calibration curve is prepared by measuring the refractive index of at least three carefully made foam solutions of different foam concentrate to water proportions. The three foam solutions must be manually made using a graduated cylinder. The foam concentrate and water are extracted from the supply source such as a holding tank. The specific proportions of foam concentrate and water used for the carefully made foam solutions should be selected such that one foam concentrate proportion is greater than, one is approximately equal to, and the other is less than that expected from the proportioner. For example, if the proportioner is set to provide a 3.0 percent foam solution, specially-made foam solutions of 1.5, 3.0 and 4.5

percent foam concentrate proportions are suggested. A 3.0 percent foam solution is made by mixing 3 parts (e.g. 3 milliliters) of foam concentrate with 97 parts (e.g. 97 milliliters) of water.

The refractive index of each of the three specially-made solutions is measured using a refractometer. A graph of the refractive index versus the foam concentrate proportion for the three foam solutions is constructed. The calibration curve is established by sketching a smooth curve which best connects the three points. Then, the foam solution from the proportioner of interest can be collected and the refractive index measured. The foam concentrate proportion of this foam solution can now be determined using the graph with the calibration curve.

7.3.3 Foam. Foam qualities of interest include expansion and drainage time. These two qualities are best determined by laboratory personnel or representatives of the manufacturer/supplier because of equipment limitations. If available, a sampling trap or collector described and illustrated in NFPA 11 and NFPA 412 should be used to collect foam samples for analysis.

7.4 ASSOCIATED ALARM SYSTEMS. Test cross zoned detectors and foam releasing devices without actually releasing foam. Tests and maintenance of detectors, circuits, control units, annunciators and power supplies are as described in Chapter 3. Some alarm system test steps in addition to those described in Chapter 3 are needed.

7.4.1 Electrical Release Devices. Test foam system electrical release devices for proper function annually in conjunction with the annual discharge test. For a realistic test, it should be combined with tests of detectors and the total alarm system. If an actual foam discharge test is not needed, close control valves ahead of the alarm actuated valve(s), and disable any pump associated with foam discharge. When alarm conditions for foam discharge have been caused, solenoid actuation of the release valve should be evident from the "thump" sound. Check relay actuation to cause pump starting or other auxiliary functions. Return equipment to its normal condition after testing.

If the release device fails to operate, check voltage to the device at the control unit and at the device with the control unit in the alarm condition. If voltages are improper, troubleshoot the control unit or circuit as indicated. Cross zoned systems require an alarm condition on both initiating circuits in an area to activate the foam release solenoid valve and associated functions. If voltages are proper, check solenoid continuity with one side of the circuit open to the control unit. Solenoid resistance should normally be a few ohms. An open solenoid should be replaced. Measure coil current with an ammeter in series if a short circuited or partially short circuited solenoid is suspected. If the solenoid fails to operate with coil current of several amperes flowing, the solenoid coil is probably short circuited internally and should be replaced. Retest after solenoid replacement. After testing, return manual control valves to the normal, open condition which were previously closed to prevent the discharge of foam.

7.4.2 Cross Zoning. Test cross zoned systems annually when the electrical foam release device is tested. Confirm that alternate detectors in an area are connected to one of the cross zoned initiating circuits and that the remaining detectors are connected to the other circuit for that area. Prepare a diagram for future reference if not already available in the control unit.

Troubleshooting of a cross zoned initiating circuit is the same as for any other initiating circuit of the same class (see Chapter 3).

CHAPTER 7. SELF-STUDY QUESTIONS

Instructions: Select the correct answer(s) for each of the following questions:

Q7-1 Foam producing equipment should be checked by?

- a. Producing foam weekly
- b. Removing and pressure testing hose and foam makers weekly
- c. Visually inspecting all equipment weekly
- d. None of the above

Q7-2 Strainers for foam systems should be cleaned and checked after each use?

- a. Weekly
- b. Quarterly
- c. Annually
- d. None of the above

Q7-3 Foam concentrate quality deterioration can be observed by?

- a. Excessive sludging
- b. Yellow tint
- c. Foul odor
- d. All of the above

CHAPTER 8. GASEOUS EXTINGUISHING SYSTEMS

8.1 GENERAL. Gaseous extinguishing systems can be divided into three general categories:

8.1.1 Local Application Systems. Local application systems are arranged to discharge the agent onto and around the burning material. They are commonly used for protection of localized hazards such as paint dip tanks, restaurant range hoods, and special motors.

8.1.2 Total Flooding Systems. Total flooding systems are arranged to discharge the agent into and completely fill an enclosed space or enclosure about the hazard to the proper concentration for extinguishment. These types of systems are commonly found in flammable liquid storage rooms, electronic equipment rooms, computer installations and transformer vaults containing oil filled equipment.

8.1.3 Hose Line Systems. Hose line systems discharge the extinguishing agent through manually operated nozzles connected by hose or by fixed piping and hose, to a fixed supply. At the present time, carbon dioxide is the only gaseous type extinguishing agent approved for manual hose line systems.

8.2 CARBON DIOXIDE SYSTEMS. Carbon dioxide is a colorless, odorless, inert gas at room temperature. It is also heavier than air. The gas is noncorrosive and electrically nonconductive. There are two general methods of applying carbon dioxide to extinguish a fire.

Method one is to create an inert atmosphere in the enclosure or room in which the hazard is located. In cases where deep-seated fires are likely, it is necessary to maintain this inert atmosphere in the enclosure for a period of time until extinguishment is complete. This method is known as total flooding.

Method two is to discharge carbon dioxide at the surface of liquids or noncombustible surfaces coated with flammable liquids or light deposits of combustible residues. This method is known as local application. No enclosure is needed around the hazard, but it is essential in local application that the fire be completely extinguished without any possibility of reignition.

As carbon dioxide is electrically nonconductive, it is used extensively for the protection of electrical equipment. The nondamaging characteristics of carbon dioxide make it attractive as an agent for rooms containing high value contents such as computer rooms and computer tape vaults. In addition, no post-fire clean-up is needed because of carbon dioxide discharge.

Discharging large quantities of carbon dioxide to extinguish fires may create hazards to personnel. A carbon dioxide cloud from the discharge may seriously interfere with visibility during and immediately after the discharge period. In addition, the noise of discharge may frighten people who have not experienced it previously or been prepared as to what to expect. At

concentrations typically required for extinguishment in total flooding systems, carbon dioxide may cause serious harm, possibly death. Oxygen deficient atmospheres will be produced where extinguishment depends on creating such an atmosphere in an enclosed space or room, especially in rooms with total flooding systems. They also may be produced by any large volume of carbon dioxide drifting and settling in adjacent low spaces, such as cellars, tunnels, or pits.

Hazards of oxygen deficient atmospheres can be controlled by installing warning systems and devices, establishing specific emergency procedures, delaying discharge of the carbon dioxide, and by other similar steps. Protective equipment should be provided to permit the rescue of personnel trapped in the room, if fire department response is not expected to be prompt.

The principal property limiting the use of carbon dioxide is its low cooling capacity compared with water. The problem of providing enough carbon dioxide to extinguish some types of fire completely without danger of reignition, may rule out using a carbon dioxide system despite other factors that may make its use desirable.

Carbon dioxide used as an extinguishing agent is stored in liquid form under its own vapor pressure, providing its own pressure for discharge. As long as liquid is present, the pressure at a given temperature is constant. As the liquid temperature increases, so does the pressure, up to the critical temperature of 87.8°F. Above this point no liquid is present, and pressure depends on percent filling (Figure 8-1).

There are two general types of carbon dioxide extinguishing systems: high pressure and low pressure.

8.2.1 High Pressure Systems. High pressure cylinders are used to store liquid carbon dioxide at ambient temperature (Figure 8-2). Normal cylinder pressure is nominally 600 psi. The pressure inside the cylinder is directly affected by the temperature where the cylinder is placed. The maximum allowable temperature for storage areas is 130°F and the minimum is 32°F.

Overfilling the cylinder can cause overpressurization. An increase in temperature causes the liquid inside the cylinder to expand. This expansion does not increase pressure inside the cylinder if there is a vapor space for the liquid to expand into.

However, if the container becomes full, pressure rises rapidly with an increase in temperature. To prevent this type of overpressurization, cylinders are filled with carbon dioxide equivalent to 68% of the weight of water the cylinder can hold at 60°F.

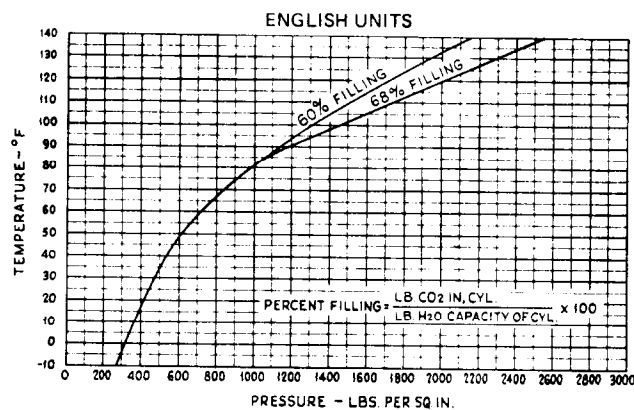


FIGURE 8-1
PRESSURE IN CARBON DIOXIDE CYLINDERS AT
VARIOUS TEMPERATURES

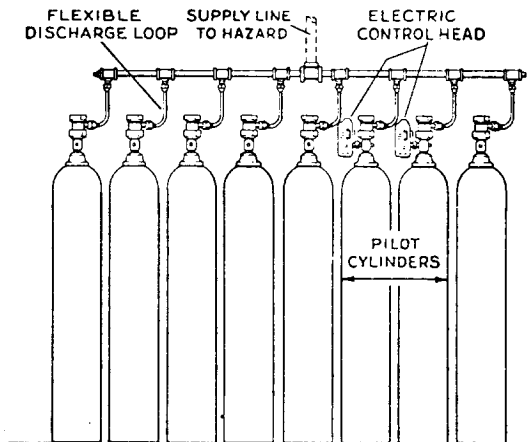


FIGURE 8-2
TYPICAL CYLINDER ARRANGEMENT FOR
HIGH PRESSURE CARBON DIOXIDE SYSTEM

For safety purposes, the high pressure cylinders have a frangible disc designed to burst at 3,000 psi to prevent rupture of the cylinder as a result of overpressurization.

8.2.2 Low Pressure Systems. Low pressure systems use a pressure vessel maintained at 0°F by insulation and refrigeration equipment (Figure 8-3). At this temperature and with the pressure of approximately 300 psi inside the container, the carbon dioxide is stored as a liquid. The filling density will not affect the pressure in the tank as long as vapor space is available for liquid expansion.

Because the storage container is mechanically kept at low temperature, the containers are usually filled to 90 to 95% of capacity. For safety purposes, relief valves are provided to prevent overpressurization. The relief valves have a diaphragm valve set to bleed off vapor if the pressure exceeds 341 psi, and a relief valve set to operate at 357 psi for a more rapid release if the pressure continues to rise. There is also a frangible disc designed to burst at 600 psi.

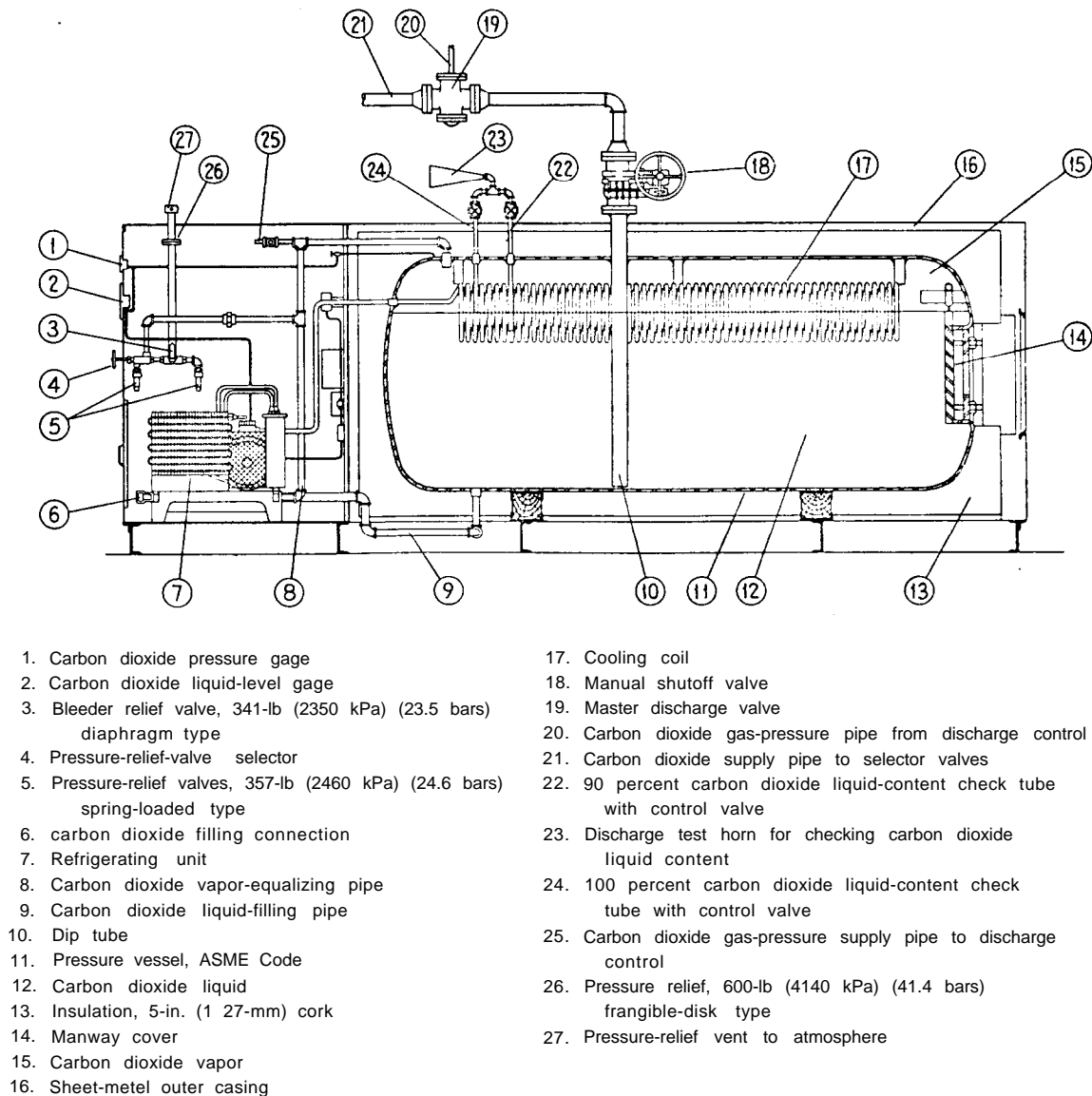


FIGURE 8-3
REFRIGERATED LOW PRESSURE CARBON DIOXIDE STORAGE TANK

8.2.3 Comparison of Low and High Pressure Systems. A comparison of the characteristics of both low and high pressure carbon dioxide systems is discussed in the following sections.

8.2.3.1 Service and Maintenance. Low pressure storage units have a liquid level gauge which continuously monitors the amount of carbon dioxide in storage. In addition, the refrigeration system for low pressure systems must be checked periodically. High pressure cylinder systems require weighing the cylinders to determine the quantity of carbon dioxide (see Chapter 9).

8.2.3.2 Design Quantities. High pressure systems permit storage of almost the exact amount of carbon dioxide required to protect the hazard because of the flexibility and selection of cylinders available, ranging in size from 5 to 100 pounds. The smallest low pressure system is 750 pounds.

8.2.3.3 Hydrostatic Testing. High pressure cylinders are required to be refilled and hydrostatically tested once every 12 years. Low pressure systems do not require periodic refilling or hydrostatic testing.

8.2.3.4 Discharge Rate. Pressures in high pressure cylinders are directly affected by ambient temperatures which, in turn, affect the discharge rate of the carbon dioxide. Low pressure systems keep the liquid carbon dioxide at approximately 0°F and 300 psi at all times, which assures a more predictable discharge rate.

8.2.3.5 Multiple Hazard Protection. Low pressure systems allow automatic, simultaneous discharge for more than one hazard area on an engineered basis. Hose reels can also be attached to these systems to operate simultaneously with hazard protection.

8.2.3.6 Reserve Supply. For low pressure systems a reserve supply can be provided by merely increasing the storage unit size. High pressure systems require a complicated manifolding and valving arrangement to achieve a reserve supply. After one discharge, the reserve supply provides standby protection during the time period required to recharge the storage unit to full capacity.

8.2.3.7 Weight and Storage Space Requirements. High pressure systems require approximately 3 pounds of equipment for every pound of stored carbon dioxide. Low pressure systems require less than 2 pounds of equipment for every pound of stored carbon dioxide. Usually, low pressure systems require less floor space for storage of equal amounts of carbon dioxide. In many instances low pressure storage containers are placed outside of the buildings. Because of the space requirements, low pressure systems are often used when a large amount of carbon dioxide is required. High pressure systems allow flexibility in space requirements since multiple cylinder banks may be stored in several smaller locations. Low pressure units require one large single area for the refrigerated storage unit.

8.2.4 Operating Devices. Release of the agent occurs through operation of the Control and Release portion of the system. The Control and Release portion consists of a cylinder valve, discharge head and control head (see Figure 8-4).

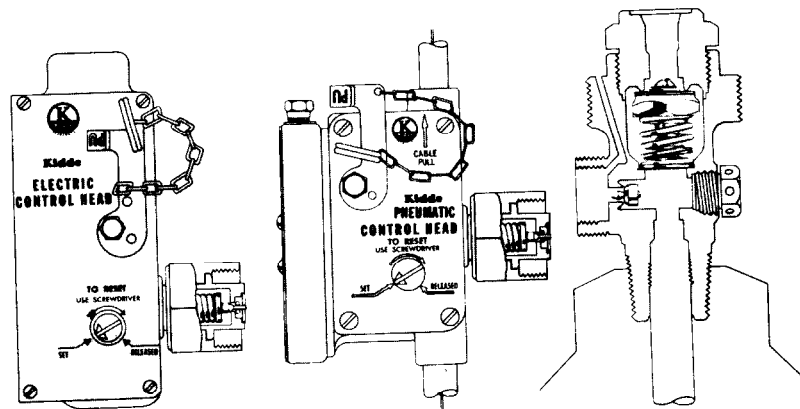


FIGURE 8-4
CARBON DIOXIDE CONTROL AND RELEASE PORTION

Pressure from the stored carbon dioxide acts on the discharge and pilot seats, illustrated in Figure 8-5, to keep the seats closed, preventing gas escape. Upon operation of an electric or pneumatic control head, the pilot seat is opened, permitting discharge of the gas. The position of all parts in the Control and Release portion during gas discharge is illustrated in Figure 8-6.

In high pressure systems having three or more cylinders, at least two cylinders are actuated directly by release devices and are called pilot cylinders. The other cylinders, referred to as "slave cylinders", are usually operated by the pressure of carbon dioxide released from the pilot cylinders. In systems having two cylinders, one serves as the pilot cylinder. The slave cylinders can be identified as no control head is present.

In low pressure systems, carbon dioxide flow is controlled by pressure operated valves in response to a timer actuated by the detection system (see Section 8.4).

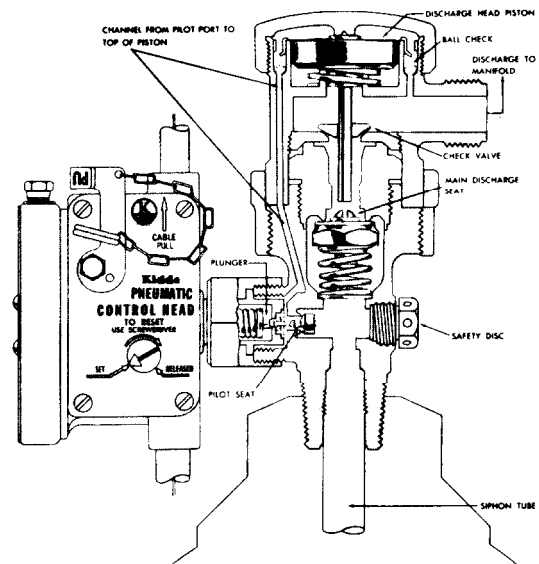


FIGURE 8-5
CARBON DIOXIDE PNEUMATIC CONTROL HEAD

8.2.5 Piping. Pipe and fittings are selected to have suitable low temperature characteristics and good corrosion resistance inside and out. Steel, copper, brass, and other materials having similar mechanical and physical properties are acceptable. Ferrous metals are galvanized. Copper tubing with suitable flared or brazed connections is also acceptable. Malleable or ductile iron fittings meeting ASTM A-395, Grade 60-45-15, are acceptable. Steel pipe meeting ASTM A-53 has good low temperature characteristics. Cast (gray) iron pipe and fittings are not used.

Valves constantly under pressure in high pressure systems must have a minimum burst pressure of 6,000 psi. For those components not under continuous pressure, such as pipe and fittings for high pressure systems, they have a minimum bursting pressure of 5,000 psi. In low pressure systems, pipe and fittings have a minimum burst pressure of 1,800 psi.

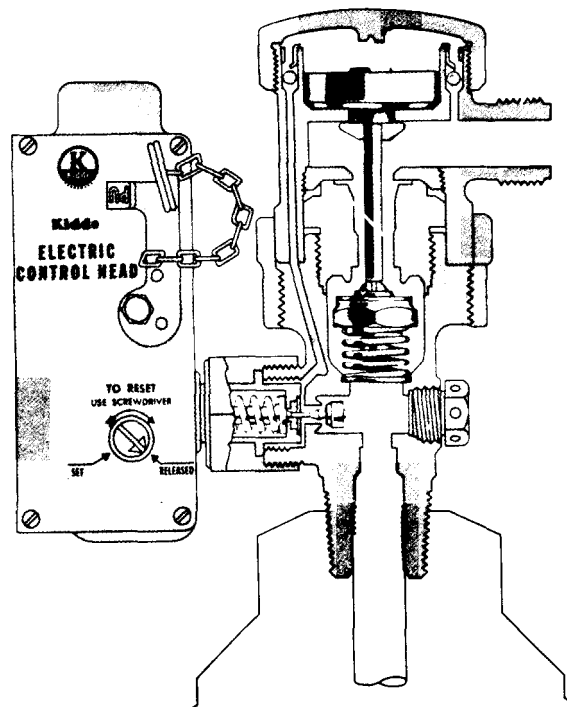


FIGURE 8-6
CARBON DIOXIDE ELECTRIC CONTROL HEAD

Between the storage tank and selector valves, black steel pipe may be used because of the larger sizes involved and the tightness from the atmosphere. The supply piping is usually routed so that it is not unnecessarily exposed to high temperatures from ovens or furnaces or to direct flame impingement prior to discharge. Hot piping causes excessive vaporization of carbon dioxide and resultant delay in effective discharge.

Pressure relief devices or other valves that prevent entrapment of liquid carbon dioxide may be installed on sections of piping that can be closed off. On high pressure systems, relief devices should operate between 2,400 to 3,000 psi, and, on low pressure systems, at 450 psi.

8.2.6 Nozzles. Nozzles are of various designs and discharge patterns. Two common types are shown in Figure 8-7. Nozzles are marked with a code number indicating the diameter in 1/32-inch increments of a single orifice standard nozzle having the same flow rate. A No. 5 nozzle, for example, has the same flow rate as a 5/32-inch-diameter standard orifice. A plus sign (+) after the number indicates a 1/64-inch larger size. Decimals are sometimes used to indicate sizes between the whole numbers.

8.2.7 Total Flooding Systems. Total flooding systems are used for rooms, ovens, enclosed machines, and other enclosed spaces containing materials extinguishable by carbon dioxide.

For effective total flooding, the space must be reasonably well enclosed so that the carbon dioxide does not leave the room before extinguishment is achieved. This is especially important in areas where deep-seated fires in

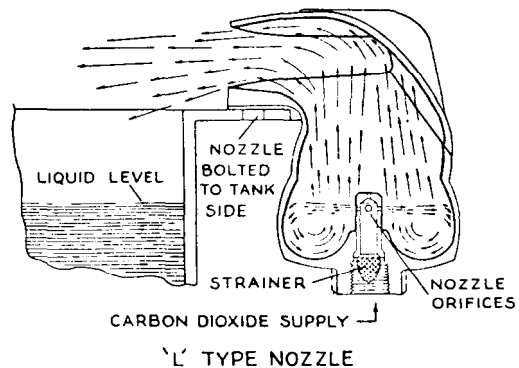
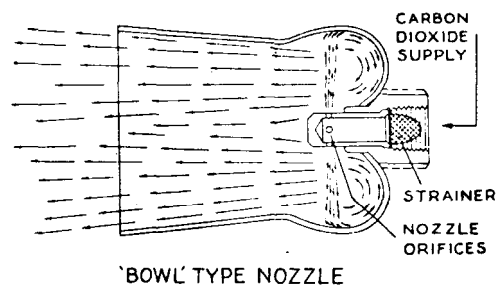


FIGURE 8-7
CARBON DIOXIDE NOZZLES

ordinary combustibles are likely, for example stacks of paper. Doors and dampers must be arranged to close automatically and ventilation equipment to shut down automatically, no later than the start of the discharge. Otherwise, additional carbon dioxide must be provided to compensate for the leakage. Automatic closing devices for openings must be able to overcome the discharge pressure of the carbon dioxide. Conveyors, flammable liquid pumps, mixers and other equipment may be arranged to automatically shut down on actuation of the protection system. A typical arrangement of a total flooding carbon dioxide system is shown in Figure 8-8.

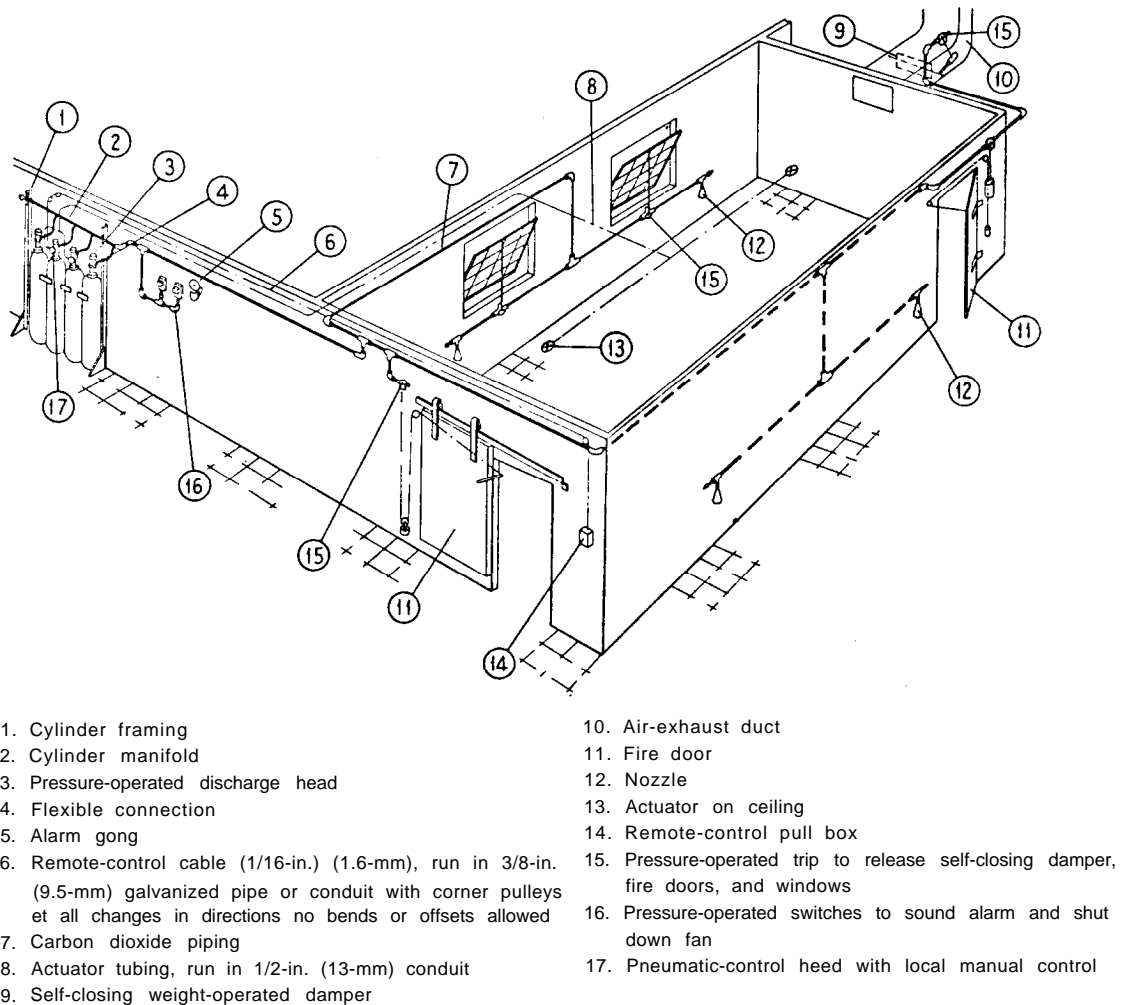


FIGURE 8-8
TOTAL FLOODING CARBON DIOXIDE SYSTEM INSTALLATION

8.2.8 Local Application Systems. Local application systems are used to protect localized hazards such as oil-filled transformers and paint dip tanks. Ventilating fans, conveyors, flammable liquid pumps, and mixers associated with the operation may be interlocked to automatically shut down on actuation of the protection system. A typical arrangement of a local application carbon dioxide system is shown in Figure 8-9. Nozzles should be positioned to completely surround the hazard.

8.2.9 Hose Line Systems. Hose line carbon dioxide systems are used to supplement fixed protection systems or portable fire extinguishers for all hazards extinguishable by carbon dioxide.

Hose line systems may be supplied either by high pressure or low pressure systems. A high pressure hose line installation is shown in Figure 8-10. The carbon dioxide may be stored in a fixed tank, as illustrated in Figure 8-10, or on a tank mounted on a mobile vehicle.

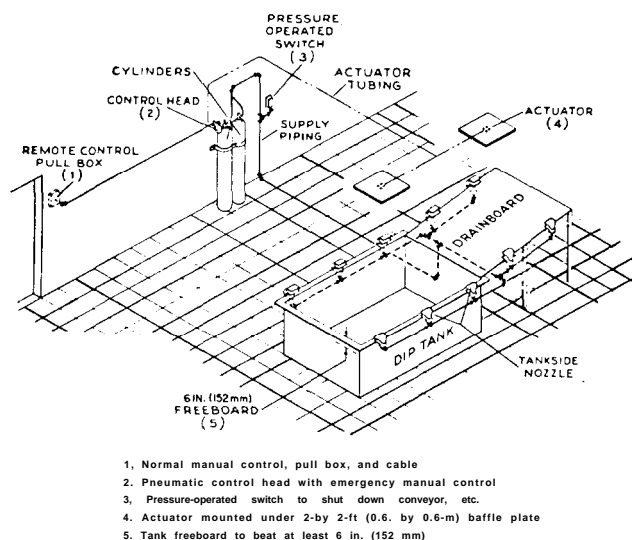


FIGURE 8-9
LOCAL APPLICATION CARBON
DIOXIDE SYSTEM INSTALLATION

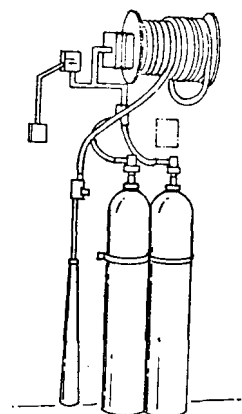


FIGURE 8-10
CARBON DIOXIDE HOSE LINE
SYSTEM INSTALLATION

8.3 HALOGENATED GAS SYSTEMS. Several types of halogenated gas systems have been developed for fire protection purposes: Halon 104, Halon 1001, Halon 1011, Halon 1202, Halon 1211, Halon 1301, and Halon 2402. The numbers relate to the chemical formulae of the gases. The first digit identifies the number of carbon atoms in the chemical molecule; the second digit identifies the number of fluorine atoms; the third digit identifies the number of chlorine atoms; the fourth digit identifies the number of bromine atoms; and a fifth digit, if any, identifies the number of iodine atoms present.

Primarily, Halon 1301 and Halon 1211 are in general use in the United States today. These two types are recognized by the National Fire Protection Association. The standards for their installation and use, published in the National Fire Codes, are NFPA 12A, Standard on Halon 1301 Fire Extinguishing Systems and NFPA 12B, Standard on Halon 1211 Fire Extinguishing Systems.

Halogenated gaseous systems are usually used in the following situations:

- Where a clean extinguishing agent is needed
- Where energized electrical or electronic circuits are to be protected
- Where flammable liquids or flammable gases are present
- Where surface burning combustible solids are protected
- Where high value objects or processes need protection

- Where carbon dioxide is inappropriate since the area to be protected is normally occupied by people
- Where availability of water or space for other types of systems is limited

8.3.1 Characteristics of Halon 1301 and Halon 1211. Generally, Halon 1301 is used in total flooding applications. Halon 1211 or Halon 1301 may be used for local application systems. At the present time there is no equipment approved for local application systems using halogenated agents. A schematic of a typical total flooding halon system is presented in Figure 8-11.

For effective fire fighting purposes, a minimum concentration of 5% is recommended for total flooding systems for surface fires of ordinary combustibles or for protecting electronic data processing or computer equipment. Deep seated fires, such as in cable insulation or stacks of paper, require much greater concentrations and extended holding times.

As opposed to carbon dioxide which extinguishes fires by displacing oxygen, Halon 1301 and Halon 1211 are believed to extinguish fires by interrupting the combustion chain reaction. Both Halon 1301 and Halon 1211 decompose when heated to approximately 900-1000°F. The thermal decomposition products of both Halon 1301 and Halon 1211 including hydrogen fluoride, hydrogen bromide, hydrogen chloride, bromine and chlorine are toxic and corrosive. Thus, Halon 1301 and Halon 1211 systems are designed to quickly achieve extinguishment, thereby reducing the room temperatures below which decomposition is not substantial. Several aspects of a testing, inspection and maintenance program are related to the elimination of detrimental factors for prompt extinguishment.

Halon 1301 is the most commonly used halogenated gas in use today. It is the least toxic of any of the halogenated gases and does not harm personnel when concentrations are between 5 and 7%. Between 7 and 10%, minor disorders of the central nervous system may occur and above 10% unconsciousness may result. Because of the toxicity concerns in addition to the noise, turbulence and localized cooling effects associated with Halon discharge, personnel evacuation from the room is often recommended. (For additional information on Halon 1301, refer to NFPA Standard 12A.) One principal use of Halon 1301 is in computer rooms.

Halon 1211 is toxic to people when concentrations exceed 4%. This precludes its use as a total flooding agent for areas occupied by personnel. Halon 1211 is normally used in portable extinguishers which do not allow a significant concentration to develop in a space to cause a hazard for people.

8.3.2 Storage. Equipment for Halon fire extinguishing systems is similar to that utilized for high pressure carbon dioxide systems (Section 8.2.1). Halon 1301 is stored in a cylinder superpressurized with nitrogen to 600 psi (at 70°F) to provide an expellent pressure for the agent in excess of the agent's normal vapor pressure. Also used for Halon agent storage are spherical containers. Storage containers for halogenated systems are illustrated in Figure 8-12. Since the design concentrations for halon are typically much less than carbon dioxide, the amount of halon agent stored is also less than carbon dioxide protecting the same space.

8.3.3 Operating Devices. Operating devices for total flooding halon systems are similar to those for high pressure carbon dioxide systems, described in section 8.2.4.

Item	Quantity	Description
1	1	CYLINDER ASSY. WITH 15—45 LBS. OF HALON 1301— PRESSURIZED WITH NITROGEN to 600 PSIG @ 70° F
2	1	DISCHARGE HEAD—PILOT OPERATED
3	1	SOLENOID PILOT VALVE ASSEMBLY WITH PRESSURE GAUGE
4	1	PILOT CONNECTION KIT CONSISTING OF 1 FLEXIBLE PILOT HOSE— $\frac{3}{16}$ " X 16" LG. AND 1 ELBOW— $\frac{1}{4}$ " FLARE X $\frac{1}{4}$ " 'M.N.P.T.
5	1	$\frac{1}{2}$ " FLEXIBLE CONNECTOR
6	1	CYLINDER MOUNTING KIT
7	1	PRESSURE SWITCH—4 POLE
8	2	RADIAL NOZZLE
9	1	WARNING SIGN
10	1	SYSTEM NAMEPLATE
11	1	SYSTEM MANUAL
12	1	INSTRUCTION SIGN

System Arrangement

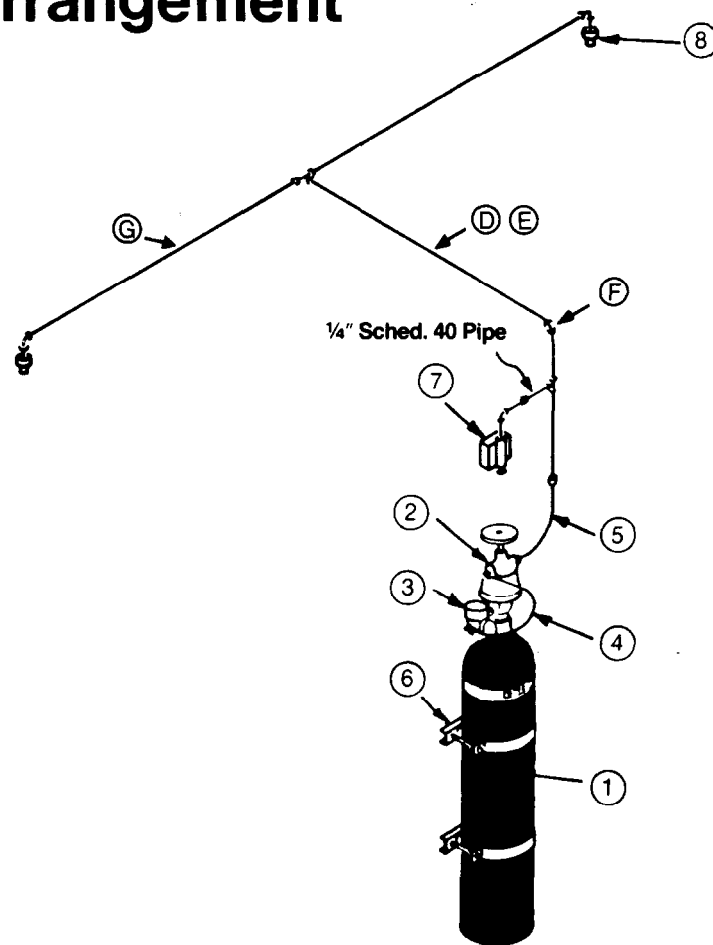


FIGURE 8-11
TOTAL FLOODING HALON SYSTEM

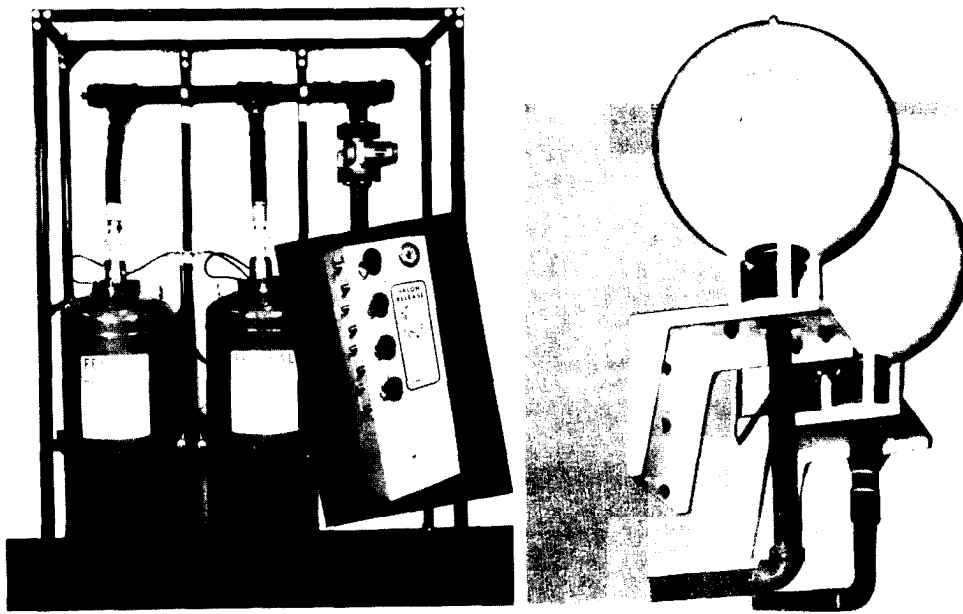


FIGURE 8-12
HALON STORAGE CONTAINERS

8.3.4 Piping. Piping must be noncombustible, have suitable low temperature characteristics and not be highly sensitive to corrosion. Steel, copper, brass, and other materials having similar mechanical and physical properties are acceptable. As with carbon dioxide systems, cast (gray) iron piping and fittings are not permitted. Pressure relief device requirements and piping installation is similar to that for carbon dioxide systems (see section 8.2.5 for more details).

8.3.5 Nozzles. As with carbon dioxide, halon nozzles are selected for the specific application based on discharge rate and gas distribution requirements. Nozzles are marked to indicate the nozzle diameter. In local application systems, nozzles should be directed at the hazard protected. A Halon 1301 nozzles for total flooding applications are illustrated in Figure 8-13. Nozzles may be connected directly to the storage container, thereby eliminating the piping system (see Figure 8-14).



FIGURE 8-13
HALON NOZZLES

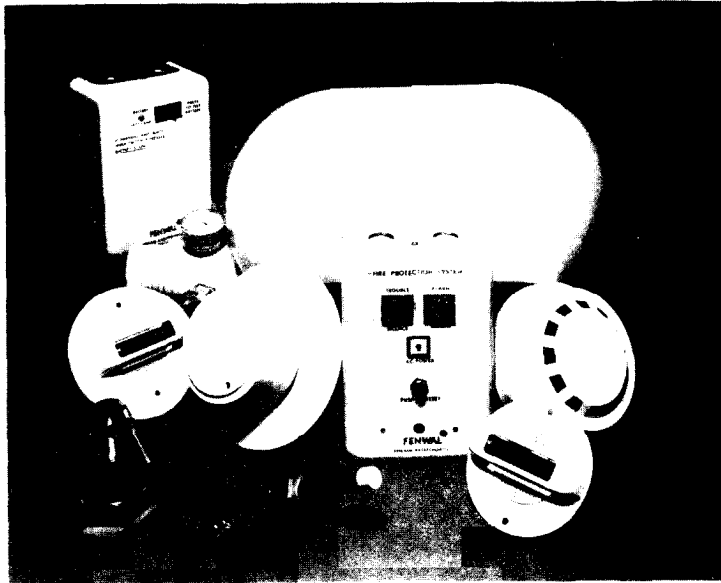
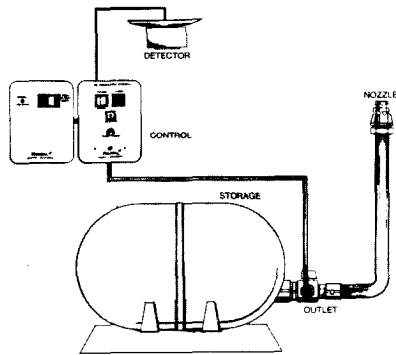


FIGURE 8-14
SELF-CONTAINED HALON SYSTEM

8.4 ASSOCIATED ALARM SYSTEMS. The alarm systems described in Chapters 2 and 3 can be used to activate gaseous extinguishing agents. However, there are some special considerations for alarm systems for gaseous systems because of possible toxic effects on personnel, the need for reasonably fast response, and reliable operation.

The response of gaseous extinguishing systems is not usually as urgent as foam agents, since the gaseous agents are more quickly discharged. Personnel safety from the possible toxic effects of the agents used is another consideration impacting the speed requirement. Fixed temperature, rate of rise and/or smoke detectors are frequently used as initiating devices.

For gaseous system, false discharge of the agent can be very expensive in terms of refilling costs. Cross zoning as described for foam extinguishing systems, is frequently used for gaseous extinguishing systems to reduce the chance of a false discharge. The first detector (zone) actuated is usually arranged to cause a local audible and/or visual signal. The second detector (zone) actuation causes a distinctive local signal to warn personnel that the extinguishing agent is about to be released. After a short time delay, the extinguishing agent is discharged.

Some gaseous extinguishing systems, usually those protecting populated spaces, have an abort feature to avoid unnecessary discharge of an expensive, possibly toxic gaseous agent. Extinguishing systems with the abort feature have a time delay between actuation of the second (or only) detector and release of the agent. The delay may be factory set or adjustable. It is usually set in the range 15 to 60 seconds to allow time for personnel to leave the area or extinguish the fire before release of the agent and to allow for manual interruption of the agent release sequence. If the situation is not dangerous, the sequence can be interrupted by a manual abort switch. When the detectors and control unit have been restored to their normal condition, the abort switch can be restored. The abort switch is usually designed to be held in (until the control panel is reset) so that the agent discharge cannot be accidentally impaired when the switch is unattended.

8.4.1 Initiating Devices. Any of the detectors discussed in Chapters 2 and 3 may be used as initiating devices to activate gaseous extinguishing agents. Frequently used detectors for gaseous agents are spot type ionization smoke detectors and rate compensated heat detectors. Factors affecting detector effectiveness, such as electrical power and air pressure, if pertinent, are supervised.

One or two manual methods for release of the gaseous agent are usually provided:

- 1 Manual fire alarm devices, similar to the noncoded devices described in Chapters 2 and 3, are frequently connected to the alarm system control unit to cause immediate discharge of the gaseous agent, regardless of cross zoning and time delays otherwise provided.
- 1 Manual devices may also be connected electrically to cause direct release of the agent, independent of the alarm system.
- 1 Direct mechanical release of agent may be achieved by manual actuation of a control valve.

Whether the agent release is caused by an alarm control unit auxiliary output or by an independent manual method, there should be an alarm at the alarm system control unit. Manual release of the gaseous agent usually causes an alarm by actuating a pressure switch which senses the increase in pressure in the gas line or manifold between the release valve(s) and the nozzles.

8.4.2 Circuit Arrangement and Function. The normal circuit arrangement for a building alarm system to release a gaseous extinguishing agent is the same as for a building system with added features such as cross zoning, the abort feature, manual release of agent, and other specific auxiliary functions of the alarm system. Alarm systems which release a gaseous extinguishing agent use auxiliary alarm outputs to segregate the protected area and reduce dispersion and dilution of the agent. Typical auxiliary functions are fan shutdown, door (and window) closure, and closure of air handling system dampers. Gaseous agent releasing alarm systems applied to computer room installations also shut down computer power at the time the agent is released to eliminate the heat source for possible electrical fires.

A typical sequence of alarm system initiated events in a computer room installation which includes all the usual features is:

- Detection of fire by first detector in an area causes local and remote alarm indication, fan shutdown, door and damper closure and other miscellaneous auxiliary functions through interlocks with building systems.
- Detection of fire by second detector in the area (cross zoned with first detector) causes a distinctive local audible signal and initiates time delay during which agent release and computer power shutdown may be aborted.
- At end of an adjustable delay (nominally 20 seconds), assuming the release is not aborted, computer power is shut down and the extinguishing agent is released into protected area.

8.4.3 Alerting Devices. Alerting devices should be provided outside of an area protected by a total flooding system, warning people that the system has been discharged. The alerting means may consist of a visual indication. A warning sign should also be included to discourage unauthorized personnel from entering the room until it has been sufficiently ventilated to remove the agent.

CHAPTER 8. SELF-STUDY QUESTIONS

Instructions: Select the correct answer(s) for each of the following questions.

Q8-1 Carbon dioxide is recommended for fires in electrical equipment because it is electrically conductive.

- a. True
- b. False

Q8-2 Carbon dioxide extinguishing systems may create hazards to personnel by:

- a. The "cloud" interfering with visibility
- b. The frightening noise
- c. Creation of an oxygen deficient atmosphere
- d. All of the above

Q8-3 The normal pressure in a high pressure carbon dioxide cylinder is:

- a. 100 psi
- b. 500 psi
- c. 600 psi
- d. 1000 psi

Q8-4 Low pressure carbon dioxide systems are maintained at a temperature of:

- a. 42°F
- b. 32°F
- c. 0°F
- d. -20°F

Q8-5 High pressure carbon dioxide cylinders require hydrostatic testing while low pressure storage tanks do not.

- a. True
- b. False

Q8-6 Low pressure carbon dioxide systems require less equipment per pound of stored carbon dioxide than high pressure systems.

- a. True
- b. False

Q8-7 Carbon dioxide nozzles are marked with numbers, for example No. 3. This number means:

- a. The nozzle has been coated with No. 3 dye
- b. The nozzle will discharge the equivalent of a 3/32-inch standard orifice
- c. The nozzle will discharge the equivalent of a 3/8-inch standard orifice
- d. The No. 3 identifies the manufacturer's serial number only

Q8-8 The numbers following the word "Halon" in describing a specific gas relate to:

- a. The manufacturers identification
- b. Nothing; the numbers are picked at random
- c. Chemical formulation
- d. The number of processes involve in production of the gas

Q8-9 The following are the principal types of Halon used for fire extinguishing systems in the United States:

- a. Halon 1011
- b. Halon 1202
- c. Halon 2402
- d. None of the above

Q8-10 The concentration level at which Halon 1211 becomes toxic to people is:

- a. 2%
- b. 4%
- c. 6%
- d. 10%

Q8-11 The method used to delay the discharge of a gaseous extinguishing system is:

- a. Cross zoning of fire detectors
- b. The manual abort feature
- c. A time delay period
- d. All of the above

Q8-12 A typical arrangement of a cross zoned detection system for a Halon extinguishing system in a computer room would:

- a. Discharge the Halon immediately after activation of the first detector zone
- b. Provide an audible alarm upon activation of the first detector and allow the fans to keep running
- c. Discharge the Halon after a time delay period following activation of the second detector zone
- d. Discharge the Halon after a time delay period following activation of the first detector zone

CHAPTER 9. INSPECTION, TESTING, AND MAINTENANCE OF GASEOUS SYSTEMS

Inspect all systems as indicated in this chapter to be sure they are in operating condition. Regular service contracts with the manufacturer or installer are recommended. Inspection and test frequencies for gaseous extinguishing systems are summarized in Table 9-1.

TABLE 9-1
SUMMARY OF INSPECTION AND TEST FREQUENCIES
FOR GASEOUS SYSTEMS

	Weekly	Monthly	Semi- Annually	Annually
1. Check nozzles and hand hose lines		x		
2. Weigh cylinders			x	
3. Check liquid level in low pressure CO ₂ storage tanks X ^a				
4. Check devices and connections of low pressure CO ₂ systems for leakage				
5. Test tank alarm pressure switch and identification device			X ^a	
6. Conduct actuating and operating tests of gas cylinders				x
7. Hydrostatic test of cylinders and hoses		(See section 9.1.1 and 9.2)		
8. Check cross-zoning initiating circuit				x

a

Frequency may be increased to annually for supervised systems

9.1 CARBON DIOXIDE SYSTEMS.

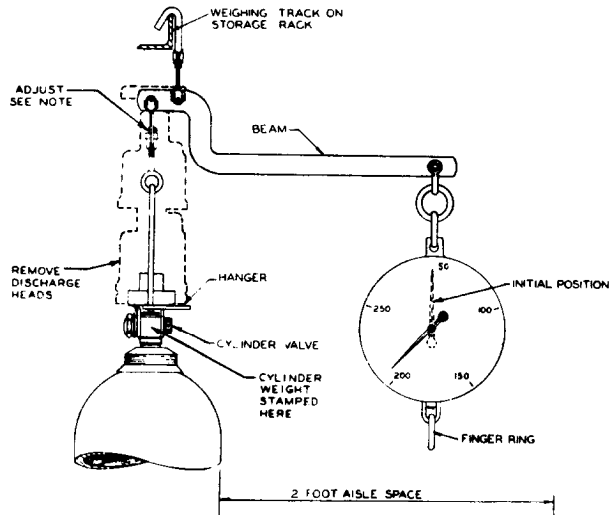
9.1.1 High Pressure Systems. Check hoses and nozzles, cylinders, and cylinder pressure as follows: a) monthly check that all nozzles and hand hose lines are clear, undamaged and in the proper position and b) monthly check that all operating controls are properly set.

Weigh cylinders semiannually and replace any that show a weight loss of greater than 10 percent. To weigh cylinders:

- Loosen each cylinder support and disconnect each discharge head. Discharge heads are designed to be removed and replaced without tools.
- Weigh cylinders with a beam scale (Figure 9-1), if available, or with a platform scale. To weigh with a platform scale, remove the cylinders completely from the rack and lift them on to the scale.

Test cylinders and hoses hydrostatically as follows:

- Hydrostatically test cylinders to a minimum pressure of 3,000 psi.



NOTE
TO WEIGH - LOOSEN CYLINDER CLAMPS, POSITION HANGER ON CYLINDER VALVE.
PULL DOWN ON FINGER RING UNTIL SCALE BEAM IS HORIZONTAL
AND CYLINDER IS JUST OFF FLOOR. ADJUST HANGER ARM IF NECESSARY.
READ WEIGHT DIRECTLY.

FIGURE 9-1
BEAM SCALE PORTABLE CYLINDER WEIGHING DEVICE

The frequency for testing is as follows:

- If discharged after five years from date of last test, perform hydrostatic test.
- If not discharged after twelve years from date of last test, discharge cylinder and perform hydrostatic test.

Hydrostatically test hoses to a minimum pressure of 2,500 psi. The frequency of testing is every 5 years. After discharge of the agent, the Control Head parts do not require replacement. Typically, the Control Head can be easily reset with a screwdriver. If facilities with the expertise for testing are not available, contact fire extinguisher contractors to perform the tests.

9.1.2 Low Pressure Systems. Check nozzles, pressure and level gauges, and for leaks in all devices weekly. Weekly, check and record the reading on the liquid level gauge of all storage tanks. Refill tanks when the quantity is less than the minimum required to protect the largest single hazard, including any required reserve supply.

Monthly check to see that all nozzles are clear and in the proper position and that all operating controls are properly set. Monthly check for leaks on all devices and connections under continuous pressure, including valve packing glands, screwed connections and safety relief valves.

Semiannually test the tank-alarm pressure switch and the operation of the alarm bell or light by reducing and increasing the pressure. Perform this test as follows:

- Close valve on the piping from the vapor space to the alarm pressure switch.
- Remove the test plug to reduce pressure
- Increase pressure by connecting a high pressure cylinder to the test opening.
- After testing, disconnect high pressure cylinder, replace test plug, and reopen valve on the alarm pressure switch piping.
- If bell or light fails to operate on pressure test, repair or replace, and test again.

Check the liquid level and pressure gauges for accuracy once each year. Replace frangible discs on the storage tanks once every 5 years. Maintain refrigeration equipment according to manufacturer's instructions. The weekly liquid level check and semi-annual tank-alarm pressure switch and alarm may be performed annually when the system is supervised, such that continuous checking of these components can be performed at a monitored location.

9.2 HALOGENATED SYSTEMS. Hoses should be checked as for high pressure systems.

For total flooding system, the room enclosure is an important parameter affecting the system effectiveness. Thus, the "tightness" of the room should be checked annually by making sure that all seals are still in place. Where practical, the operation of the release mechanisms for doors, windows and dampers should be checked, in addition to the operation of the door, window and/or damper itself. Also on an annual basis, the operation of any auxiliary functions should be checked, such as equipment shutdown, alerting devices, *etc.*

The following steps are recommended for the inspection and maintenance of halogenated systems.

Monthly check to see that all nozzles are clear, undamaged, and in proper position. Also check that all operating controls are properly set. Semiannually check weight and pressure of containers. (See procedures for verifying carbon dioxide cylinders.)

- If the container has a loss in net weight of more than 5% or a loss in pressure (after adjusting for temperature) of more than 10%, either refill or replace the container.
- If a factory charged nonrefillable container which does not have a pressure indicator shows a loss in net weight of more than 5%, replace the container.

A thorough check of the systems and all its components should be done once a year. Annually test all actuating and operating devices for proper operation. A cylinder containing carbon dioxide or freon may be used in place of Halon cylinders to minimize the cost of a discharge test, or a simulated test of pressure operated devices may be conducted. Hydrostatically test cylinders at the following intervals:

- If discharged after five years from date of last test, perform hydrostatic test.
- If discharged after 20 years from date of last test, perform hydrostatic test.

If the cylinder appears to be physically damaged or corroded, the cylinder should be removed and tested promptly. As with carbon dioxide total flooding systems, an annual inspection should be performed to insure that the room is well sealed. Where possible, operation of the release mechanisms for closing devices in the room openings should be checked.

9.3. TESTING AND MAINTENANCE OF ASSOCIATED ALARM SYSTEMS. Testing and maintenance of detectors, circuits, control units, annunciators, relays and power supplies for carbon dioxide and halogenated gas systems are as described in Chapter 3. Some additional steps are required to test cross zoned detectors, electrically operated releases for gaseous agents, and the abort feature.

9.3.1 Release Devices and Auxiliary Functions. Test electrically operated release devices for gaseous extinguishing systems annually. Combine the test with tests of detectors and the total alarm system. If an actual discharge test is not desired, be sure to prevent gas discharge and computer power shutdown, while allowing observation of electrical functions. This may require valve closure or partial disassembly of diaphragm piercing solenoid plunger type valves and manual override of the computer shutdown feature. Refer to system instructions from the equipment manufacturer or installing company. The same method, once determined, is normally used for testing manual devices electrically connected to cause direct actuation of gas release devices.

After taking necessary steps to prevent gaseous discharge, create the necessary alarm conditions to actuate the extinguishing system by actuating detectors or manual initiating devices. At the end of the time delay interval, release device actuation should be evident by sound or visual observation. Verify that relays for auxiliary functions actuate. Take notes on which event relays are actuated at the first cross zoned detector alarm, second cross zoned detector alarm, and at the end of the timer interval. Note the amount of time delay between the second detector actuation and the delayed functions.

If release devices or auxiliary functions fail, check appropriate output voltages at the control unit and at the failed device with the control unit in the alarm condition. If voltages are improper, troubleshoot the control unit or circuit as indicated. Cross zoned systems require an alarm condition on both initiating circuits in an area to actuate release devices and some auxiliary functions. If a timed function fails, check input voltage to the timer and the delayed output voltage from the timer with a voltmeter. Replace the timer if input is proper but output is not.

If voltages are proper, check solenoid and relay coil continuities with one side of their respective energizing circuits open to the control unit. See testing and maintenance for foam systems, Section 7.3.1, for instructions for this test. Replace defective devices and/or wiring.

9.3.2 Cross Zoning. Check cross zoned systems annually when the gaseous system release device is tested. Test procedures are the same as for foam systems (Section 7.3.2). Troubleshoot a cross zoned initiating circuit the same as any other initiating circuit of the same class.

9.3.3 Abort Feature. In gaseous extinguishing systems with an abort feature, test the feature annually, along with other elements of the system. To test the abort feature, first determine the timer setting from prior test records or installation data. Then, cause first and second cross zoned detector alarms. The second detector alarm starts the timed period during which gaseous agent release and other abortable functions may be activated. Operate the abort switch approximately in the middle of the time interval. The test should normally be performed with agent release and computer shutdown features disabled as described in testing release and auxiliary devices, Section 9.3.1. At the end of the timed interval confirm that the aborted functions do not occur. Possible causes of abort failure are as follows:

- A defective abort switch
- A defect in the wiring between the abort switch and the main control unit
- Improper abort feature installation or an improper timer setting (low)

During troubleshooting, disable the extinguishing agent release and the computer shutdown feature, if provided. Check the abort timer setting according to the manufacturer's instructions. If the timer setting is quite low, 15 seconds or less, increase the setting to 20 seconds or more as determined by local authorities to be adequate to prevent unnecessary discharge of the agent.

If actuating the abort switch has no effect, check the switch continuity with an ohmmeter while actuating it disconnected from its wiring. If the switch continuity shows alternating readings of zero ohms and infinite resistance, as it should when being repeatedly actuated, check to see that the off and on positions of the switch are not reversed. Such reversal may be caused by connecting the wires to the wrong pair of switch terminals or inverting the switch when mounting it. If the switch has no defect, check its circuit continuity with an ohmmeter at the control unit and with at least one wire disconnected from the control unit. Observe switch action at the ohmmeter by actuating the switch repeatedly. Correct any circuit defects or wiring errors. Replace the switch if it is defective.

CHAPTER 9. SELF-STUDY QUESTIONS

Instructions: Select the correct answer(s) for each of the following questions.

Q9-1 During semiannual weighing high pressure carbon dioxide cylinders should be replaced when a weight loss exceeds this percentage found:

- a. 5%
- b. 10%
- c. 20%
- d. 25%

Q9-2 What is the minimum pressure for which high pressure carbon dioxide cylinders should be hydrostatically tested?

- a. 2,000 psi
- b. 3,000 psi
- c. 4,000 psi
- d. 5,000 psi

Q9-3 Low pressure carbon dioxide storage tanks should have their liquid level and pressure gauges checked for accuracy once a year.

- a. True
- b. False

Q9-4 During semiannual weighing halon containers should be replaced or refilled when a weight loss exceeds this percentage:

- a. 5%
- b. 10%
- c. 20%
- d. 25%

Q9-5 Electrically operated release devices for gaseous systems should be tested?

- a. Monthly
- b. Quarterly
- c. Annually
- d. Only when there are signs of an abnormal condition

Q9-6 A special troubleshooting consideration of detection systems associated with gaseous extinguishing systems is?

- a. Class B wiring
- b. High voltage DC power supply
- c. The abort feature
- d. Solenoid proportioning equipment

CHAPTER 10. DRY AND WET CHEMICAL EXTINGUISHING SYSTEMS

10.1 GENERAL. Dry and wet chemical extinguishing systems can be divided into three general categories:

- **Total Flooding Systems.** Total flooding systems are arranged to discharge the agent into enclosed spaces. Such systems are used for the protection of flammable liquid storage rooms and paint drying ovens (Figure 10-1). Ventilating equipment, conveyors, flammable liquid pumps, and mixers may be interlocked with the extinguishing system shut down automatically upon discharge of the system.

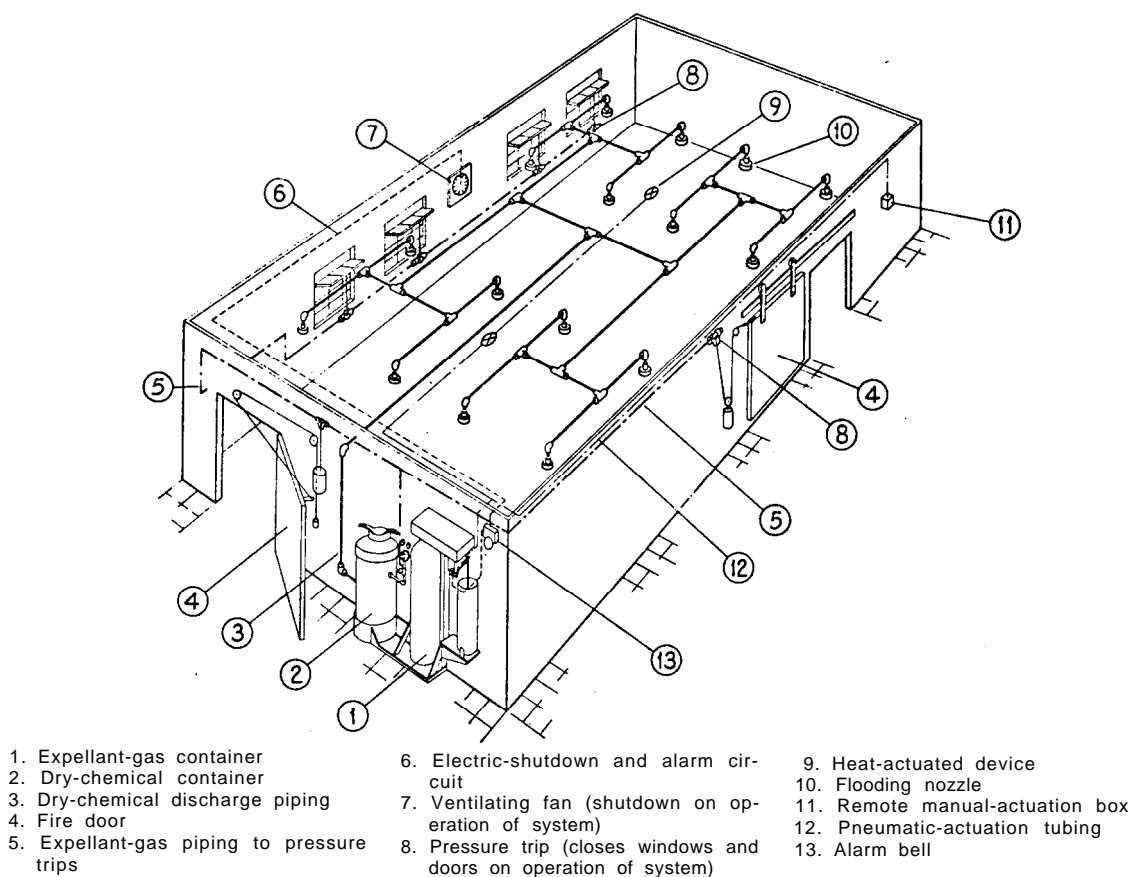


FIGURE 10-1
TOTAL FLOODING DRY CHEMICAL SYSTEM INSTALLATION

- **Local Application Systems.** Local application systems are arranged to discharge dry chemical directly on the hazard, without any enclosure (Figure 10-2). Typical local application systems are used for the protection of localized hazards such as paint dip tanks and restaurant range hoods (Figure 10-3). Ventilating fans, conveyors, flammable liquid pumps, and mixers may be interlocked to shut down automatically upon discharge of the system.

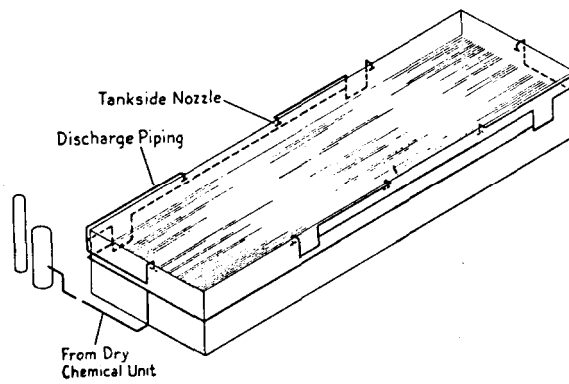
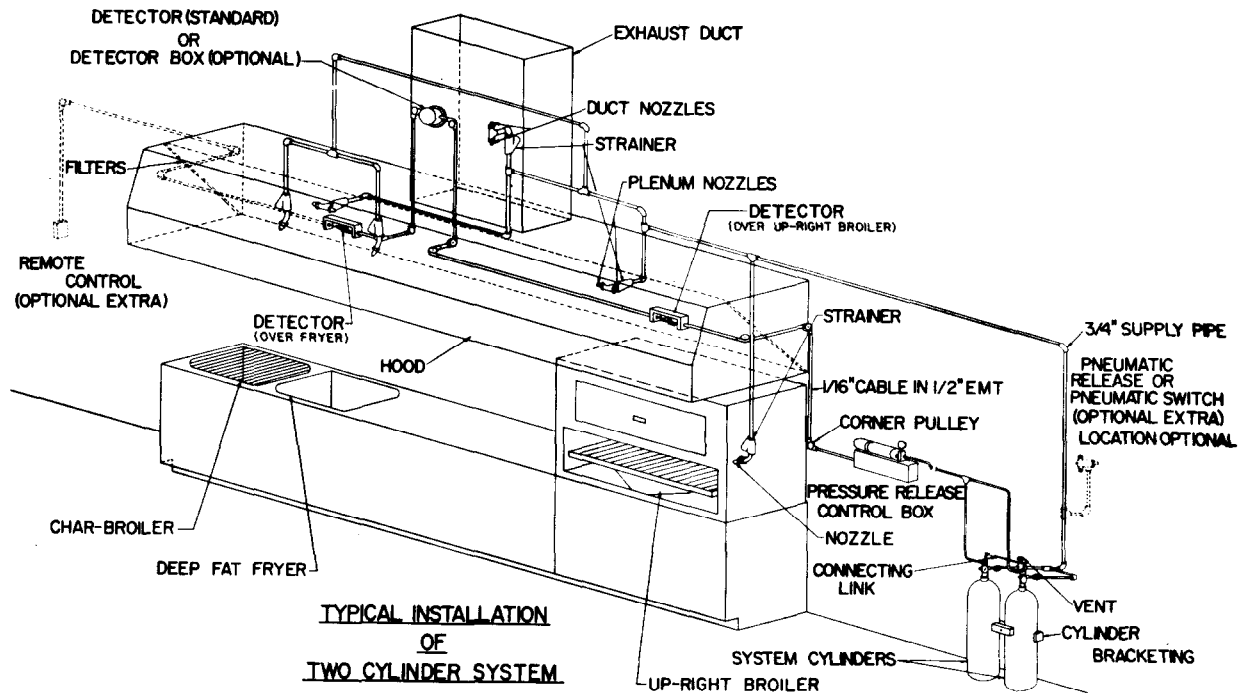


FIGURE 10-2
LOCAL APPLICATION DRY CHEMICAL SYSTEM INSTALLATION



TYPICAL INSTALLATION OF A TWO-CYLINDER SYSTEM

FIGURE 10-3
RESTAURANT RANGE HOOD WET CHEMICAL SYSTEM

- **Hose Line Systems.** Hose line systems discharge dry chemical through manually operated nozzles connected by hose or by piping and hose to a fixed supply (Figure 10-4).

Dry chemical systems are generally of the local application type, though can be used in any of the three general categories. However, wet chemical systems are limited principally to local applications, e.g. range hood protection.

Dry chemical used in approved systems is mostly sodium bicarbonate, very finely ground, to which has been added other ingredients to enable it to flow freely and resist caking. Other agents used in dry chemical extinguishing systems include potassium bicarbonate, potassium chloride, and monoammonium phosphate--multipurpose type.

Generally, wet chemical is a solution of water and a chemical containing potassium carbonate and/or potassium acetate. The system design is dependent on the specific chemical used in the solution. Thus when recharging a system, substitution with another chemical should be permitted only after a complete engineering analysis.

The dangers of dry chemicals to exposed personnel used in concentrations necessary for fire extinguishment are temporary breathing difficulty and reduced visibility. In areas using total flooding systems, suitable means should be provided to permit evacuation of personnel prior to agent discharge. In areas using local application systems where the dry chemical is not confined, there is little hazard. Contact with wet chemicals may cause some minor irritation. In addition, protection equipment should be provided to rescue personnel trapped in the room if the fire department response is not expected to be prompt.

There have been many theories as to how dry and wet chemicals extinguish fire. The more generally accepted theory is that wet and dry chemical have an inhibiting effect on the chain reaction involved in combustion. Other theories contend that (1) wet and dry chemical provides a physical blanketing, (2) oxygen in the air is diluted by carbon dioxide and water vapor produced by the fine solid particles, or (3) heat is reflected by the wet and dry chemical agent.

Dry chemical systems are used primarily for extinguishing fires in flammable liquids. Bicarbonate base dry chemical can be particularly effective for extinguishing fire in deep fat fryers caused by overheating. The interaction of the dry chemical and fat or grease prevents reignition by saponification, that is turning the fat to soap. Multipurpose dry chemical will not react with the fat or grease and can prevent the saponification reaction between the fat or grease and any bicarbonate base dry chemical subsequently used. Thus, mixing agents can be counter-productive.

Because of its coating ability, multipurpose dry chemical is also effective on ordinary combustibles such as wood, paper, or cloth when it can reach all surfaces involved in combustion. Bicarbonate base dry chemical is also effective for textile surface fires, although water should be provided to extinguish possible smoldering or deep seated fires.

Wet chemical systems are used most commonly to protect commercial kitchen ranges. The potassium-based solution has been observed to be most effective in controlling grease-related fires.

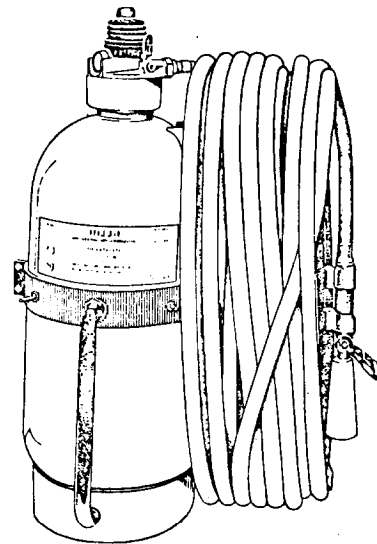


FIGURE 10-4
STORED PRESSURE DRY CHEMICAL
CYLINDER WITH HOSE LINE

Dry and wet chemical systems are not suitable for fires in materials such as cellulose nitrate that contain their own oxygen supply. They are not normally suggested for fires involving delicate electrical equipment such as telephone switchboards, computers, and certain other electronic equipment because the dry chemical will insulate the fine and delicate contacts, necessitating complete, expensive cleaning.

Monoammonium phosphate and potassium chloride are slightly acidic, and in the presence of moisture can corrode metals such as steel, cast iron, and aluminum. Sodium bicarbonate and potassium bicarbonate are slightly basic, and in the presence of moisture can corrode metals such as aluminum, aluminum brass, aluminum bronze, and titanium. Corrosion can be minimized by prompt cleanup. Most dry chemical agents can be cleaned up by wiping, vacuuming, or washing the exposed materials or surfaces. Monoammonium phosphate will require some scraping and washing if exposed surfaces were hot when the agent was applied.

Dry and wet chemical agents are not effective on metal--Class D--fires, but special dry powders are available which will extinguish fires in such metals as sodium, potassium, magnesium, aluminum, and titanium. Thus, remember that "dry chemical" and "dry powder" do not refer to the same extinguishing agent. The design testing and maintenance of dry chemical systems is addressed in NFPA 17. NFPA 17A covers the design, testing and maintenance for wet chemical systems.

10.1.1 Types of Systems. There are basically two types of dry and wet chemical systems:

10.1.1.1 Gas Cartridge. Gas cartridge systems use a container of expellent gas (typically nitrogen) which, when released by manual or automatic means, pressurizes the container of dry or wet chemical and forces the agent through the piping network or hose lines (Figure 10-5). Wet chemical systems are generally of this type.

10.1.1.2 System Pressure. Pressure systems consist of a container of dry chemical which is constantly pressurized, usually with nitrogen (Figure 10-6). The nitrogen pressure provides the necessary force to propel the agent through the piping network.

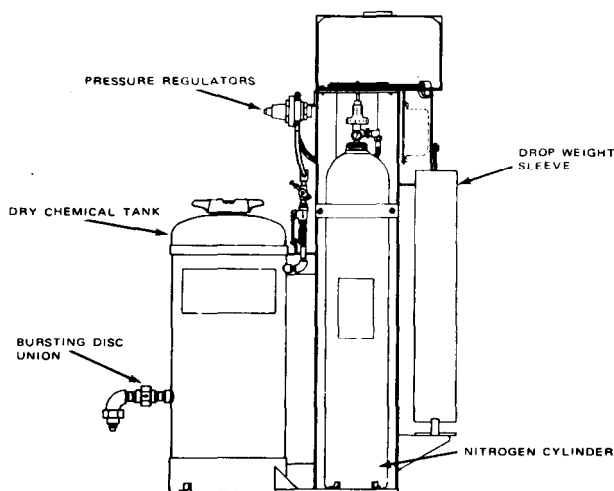


FIGURE 10-5
DRY CHEMICAL AND EXPELLENT GAS STORAGE
CYLINDERS WITH PIPING CONNECTION

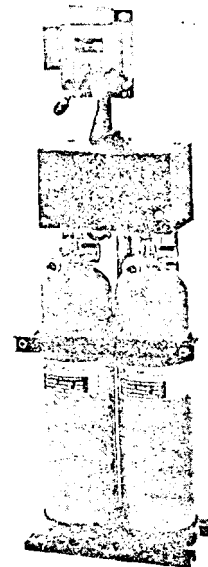


FIGURE 10-6
DOUBLE CYLINDER STORED
PRESSURE DRY CHEMICAL SYSTEM

10.1.2 System Components.

10.1.2.1 Operating Devices. Operating devices are used to release the expellent gas from its container for the pressurization of the dry or wet chemical tank or to release the dry chemical if normally stored under pressure.

In fixed systems, expellent gas is released from its container by electrically, pneumatically, or mechanically dropping a weight that opens a cylinder valve or by mechanically releasing a spring that punctures the sealing disc of a gas cartridge. When stored under pressure, the dry chemical is released by pneumatically or mechanically dropping a weight that opens the discharge valve.

Pressure trips may be used to release the weights of more than one unit for simultaneous discharge on hazards needing a greater capacity than is available for one unit. Pressure trips are operated by gas pressure taken from the low pressure side of the expellent gas regulator.

Hose line systems are actuated at the cylinder by turning a hand wheel or by moving a lever.

10.1.2.2 Piping. The distribution system should be constructed of standard weight (Schedule 40) galvanized steel pipe and standard weight galvanized steel or malleable iron fittings.

It is important that the piping system be designed so as to be "balanced", so that the pressure drop to any one nozzle will be about the same as to any other nozzle. Although dry chemical suspended in a gas may be homogeneous during flow, i.e. resembling a liquid, certain effects such as inertia and sudden expansion of the gas may cause some separation of the two phases, thereby altering the friction loss characteristics.

For example, if several nozzles were installed consecutively at right angles to a straight run of pipe, the inertia of the dry or wet chemical would carry most of it past the first nozzles. These nozzles would, therefore, discharge more gas and less agent than those farther down the piping system. To eliminate this, all branch piping is balanced by the use of tees, the agent entering the side port and leaving through the two end ports.

10.1.2.3 Nozzles. Nozzles are of various designs and discharge patterns. Nozzles for distributing the dry or wet chemical are of a type approved for the particular application. Most nozzle assemblies are equipped with a seal or cap to prevent the entry of foreign materials from depositing onto the nozzle, thereby blocking the orifice.

10.2 ASSOCIATED ALARM SYSTEMS. The alarm systems described in Chapters 2 and 3 can be used to activate dry or wet chemical extinguishing agents. Alarm systems used with dry or wet chemical systems require special considerations similar to those for foam systems and gaseous systems. The release methods for dry or wet chemical agents are similar to those for gaseous agents--an expellent gas controlled by the alarm system is used to move the agent to the fire.

10.2.1 Electrical Initiating Devices. A typical dry or wet chemical system (frequently used for cooking grills and deep fat fryers) may use rate compensated heat detectors located in the range hood. Smoke and flame detectors are not usually used for kitchen applications because of the frequent normal occurrence of both smoke and flame. Other automatic fire detectors may be used for applications of dry or wet chemical systems. Normally a pressure switch type initiating device is used to sense the release of expellent gas when the release is accomplished manually.

10.2.2 Circuit Arrangement and Function. The normal circuit arrangement for a building alarm system to release the extinguishing agent is the same as for a building system which does not cause agent release. Possible added features may be cross zoning, the abort feature, manual release of agent, and auxiliary functions such as building system interlocks (fuel shut-off, water wash-down initiation, etc.). Wiring for detectors over a kitchen range hood should be located in conduit.

Building system interlocks serve to confine the fire and extinguishing agent to the original fire area. Local application and full flooding dry chemical systems may be interlocked with building systems to cause automatic shutdown of ventilating fans, conveyors, and flammable liquid pumps and mixers when an alarm occurs.

10.2.3 Alerting Devices. Alerting devices should be provided outside of an area protected by a total flooding system, warning people that the system has been discharged.

CHAPTER 10. SELF-STUDY QUESTIONS

Instructions: Select the correct answer(s) for each of the following questions,

Q10-1 Types of areas protected by total flooding dry chemical systems are:

- a. Paint dip tanks
- b. Flammable liquid storage rooms
- c. Paint drying ovens
- d. All of the above

Q10-2 Multipurpose dry chemical is effective on Class A, B, C and D type fires.

- a. True
- b. False

Q10-3 Fixed dry chemical systems are operated automatically by:

- a. Releasing a spring which punctures a sealing disk
- b. Fusing a sprinkler which allows dry chemical to flow
- c. Dropping a weight which opens a cylinder valve
- d. All of the above

Q10-4 Nozzles for dry chemical systems are interchangeable with nozzles for carbon dioxide systems.

- a. True
- b. False

Q10-5 The circuit arrangement of alarm systems for dry chemical extinguishing systems is:

- a. Subject to monthly inspection
- b. The same as for a building system which does not cause agent releases
- c. Required to be replaced after each system operation
- d. Not U.L. listed

CHAPTER 11. INSPECTION, TESTING, AND MAINTENANCE OF
DRY AND WET CHEMICAL SYSTEMS

11.1 GENERAL. Dry chemical tanks and expellent gas assemblies using nitrogen should be located where they will not be subject to temperatures above 120°F or below -40 F. Assemblies using carbon dioxide as an expellent gas should be located where they will not be subject to temperatures above 120 F or below 32 F. Wet chemical tanks should be stored in areas with a temperature range of 32 F to 120 F. Exposure to weather or corrosive atmospheres should be minimized.

Reserve supplies of dry chemical should be stored in a clean, dry area in the original shipping containers with the lids tightly closed to prevent the entrance of moisture. The storage life of the wet chemical agent is approximately 12 years. Before replenishing a system, the dry chemical should be checked carefully to determine that it is free flowing and without lumps. The pressure or weight of the expellent gas container should be checked to assure that it is above the minimum specified by the manufacturer. Proper operation of the system is dependent upon the physical characteristics of the extinguishing agent. It is essential to use only the dry or wet chemical for which the system was designed.

Competitive brands of the same extinguishing agent may not be interchangeable. Also, different types of agents may not be chemically compatible. In particular, monoammonium phosphate can react with bicarbonate base agents producing pressures capable of rupturing the dry chemical container. As noted in Chapter 10, mixing two types of agents is not suggested as the agents may counteract each other when applied onto a burning fuel. Inspect all systems as indicated in this chapter to be sure they are in operating condition. Regular service contracts with the manufacturer or installer are recommended. Inspection and test frequencies for dry and wet chemical systems are summarized in Table 11-1.

TABLE 11-1
SUMMARY OF INSPECTION AND TEST FREQUENCIES
FOR DRY AND WET CHEMICAL SYSTEMS

		Semi- Monthly	Annually	Annually
1.	Check nozzles and hand hose lines	x		
2.	Check for physical damage to system	x		
3.	Check dry or wet chemical expellent gas cylinders		x	
4.	Check general condition of system		x	
5.	Check condition of agent			x
6.	Conduct actuating and operating tests of system			x
7.	Hydrostatic test of cylinders and hose	(see section 11.2)		

11.2 DRY AND WET CHEMICAL SYSTEM HARDWARE. Monthly, check that all nozzles and hand hose lines are clear and in the proper position and that all operating controls are properly set. Also, a cursory visual check should be made to insure that the system has not been physically damaged. Semiannually, check the expellent gas cylinders of gas cartridge systems for proper pressure or weight to ensure enough gas is available. Also, visually check the general condition of all system components. Annually open and check the dry chemical in gas cartridge and stored pressure systems to ensure it is free flowing and without lumps. Annually test all actuating and operating devices. Fixed temperature sensing elements should be replaced annually in kitchen range hood systems.

Conduct hydrostatic testing as follows:

- At least once every 12 years, hydrostatically test all dry chemical containers which are less than 150 pounds nominal capacity (based on agent weight), auxiliary pressure containers, valve assemblies, hoses, hose nozzles and fittings, check valves, directional valves, and manifolds.
- After the annual inspection, perform a hydrostatic test on the equipment that has evidence of corrosion or pitting in excess of manufacturer's limits, structural damage, fire damage, repairs by soldering, welding or brazing are noted, perform a hydrostatic test on the equipment.

Immediately after use, blow all hand hose lines and piping clear of all dry or wet chemical to prevent plugging.

11.3 ASSOCIATED ALARM SYSTEMS. The tests required for alarm systems associated with release of dry or wet chemical extinguishing agents are the same as required for similar features in foam and gaseous systems.

11.3.1 Release Devices and Auxiliary Functions. Test electrically operated release devices for dry and wet chemical extinguishing systems for proper function annually. If actual agent discharge is not desired, prevent discharge as described for gaseous agent systems in Section 9.3.1. Test auxiliary functions annually as described for gaseous agent systems. If dry chemical discharge is desired, bags or containers may be firmly attached to the nozzles to capture the agent, reducing clean-up requirements and allowing the agent to be re-cycled.

11.3.2 Special Features. Special alarm system features, such as cross zoning, abort feature and timer, and manual/electric release devices, should be tested annually the same as for foam and gas systems.

11.3.3 Troubleshooting. Follow troubleshooting guidelines for foam and gas systems, noted in Sections 7.4 and 9.3.

CHAPTER 11. SELF-STUDY QUESTIONS

Instructions: Select the correct answer(s) for each of the following questions.

- Q11-1 Dry chemical agent produced by different manufacturers may not be compatible and should not be interchanged indiscriminately.
- a. True
 - b. False
- Q11-2 Dry chemical systems should be checked annually to determine that:
- a. Its fire extinguishing properties are within acceptable limits
 - b. It is free flowing and without lumps
 - c. The actuating and operating devices are functioning correctly
 - d. All of the above
- Q11-3 After use, all hand hose lines and fixed piping systems should be blown clear of all residual dry chemical.
- a. True
 - b. False
- Q11-4 The expellent gas cylinders for gas cartridge dry chemical systems should be checked for pressure or weight:
- a. Monthly
 - b. Semiannually
 - c. Annually
 - d. Every 12 years
- Q11-5 The tests for alarm systems associated with dry chemical systems are similar to those for alarm systems of foam and gaseous systems.
- a. True
 - b. False
- Q11-6 When refilling storage containers for a wet chemical system, any wet chemical agent may be used.
- a. True
 - b. False

CHAPTER 12. OTHER FIRE PROTECTION SYSTEMS

12.1 GENERAL. Previous chapters have addressed inspection, maintenance and testing provisions for fire detection and suppression systems. Often, other fire protection measures such as smoke control systems and fire-resistant assemblies are also included in buildings. These systems will be briefly addressed in this chapter.

Smoke control systems act to limit smoke spread in buildings, maintain habitable atmospheres and limit smoke damage. Principal components of smoke control systems include fans, smoke doors and smoke dampers.

Fire resistant assemblies may include the protection of a single structural member (column, beam or truss) or the provision of a wall or floor/ceiling system. The use of fire walls and dampers are important components to preserve the integrity of wall and floor/ceiling assemblies.

12.2 SMOKE CONTROL SYSTEMS. Two typical types of smoke control systems are stairwell pressurization and zoned smoke control systems.

12.2.1 Stairwell Pressurization Systems. Stairwell pressurization systems are designed to maintain a smoke-free escape route in the stairwell. This is accomplished by slightly pressurizing the stairwell to prohibit smoke spread into the stairwell. Four basic design approaches are used in pressurized stairwells:

- a. Single injection
- b. Multiple injection
- c. Compartmented stairwells
- d. Vestibules

Single injection systems are the most common type of stairwell pressurization system. Single injection systems have one fan per stairwell, located either at the top or bottom of the stairwell, as shown in Figures 12-1 and 12-2. An exhaust outlet must be provided at the opposite end of the stairwell from the fan. The exhaust outlet may consist of a vent or a doorway.

Several pressurization points are provided in multiple injection systems. The pressurizations points may be provided by several fans or one fan with a duct having numerous outlets as shown in Figures 12-3 and 12-4. The duct may be located within the stairwell enclosure. As with single injection systems, an exhaust outlet is necessary.

The use of compartmented stairwells conceptually divides a tall stairwell (in excess of 15-20 stories) into several shorter stairwells. Each compartment may be treated similar to a single or multiple injection system, as shown in Figure 12-5.

Finally, a vestibule may be included at the stairway door leading into a corridor. The use of a vestibule with any of the above systems may be used to decrease the amount of air leakage from the stairwell. By decreasing the leakage potential, the system reliability is increased. Vestibules may be independently pressurized by a fan to further enhance the system reliability.

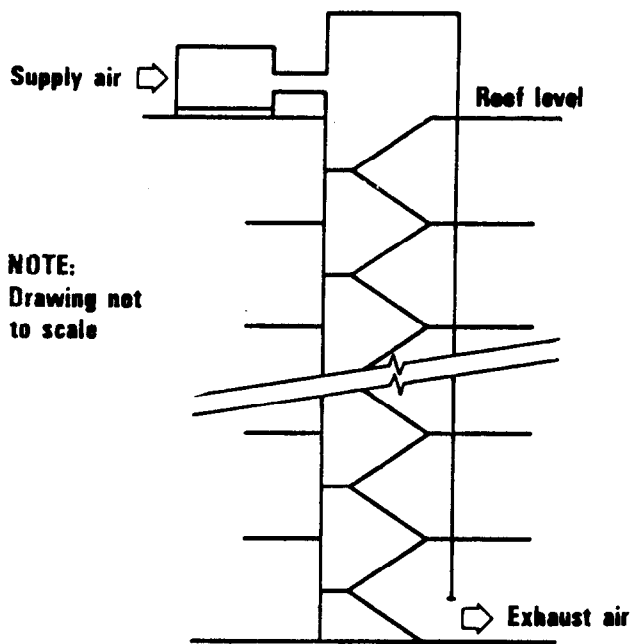


FIGURE 12-1
DIAGRAM OF TOP INJECTION STAIRWELL
PRESSURIZATION SYSTEM

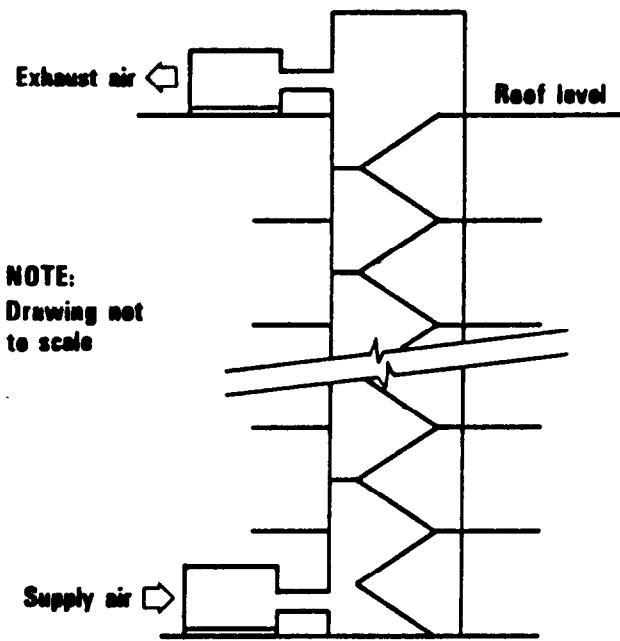


FIGURE 12-2
DIAGRAM OF BOTTOM INJECTION STAIRWELL
PRESSURIZATION SYSTEM

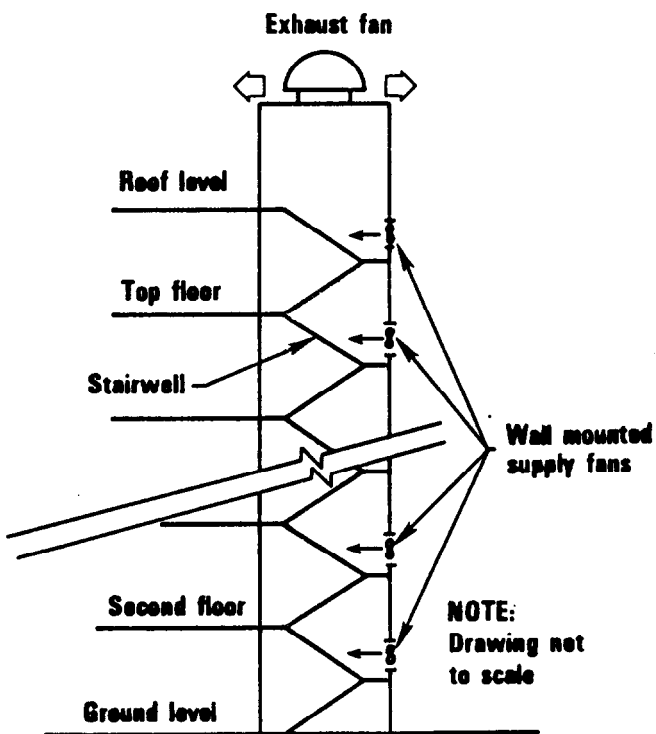


FIGURE 12-3
MULTIPLE INJECTION SYSTEM WITH AN
EXHAUST FAN AND SEVERAL WALL
MOUNTED SUPPLY FANS

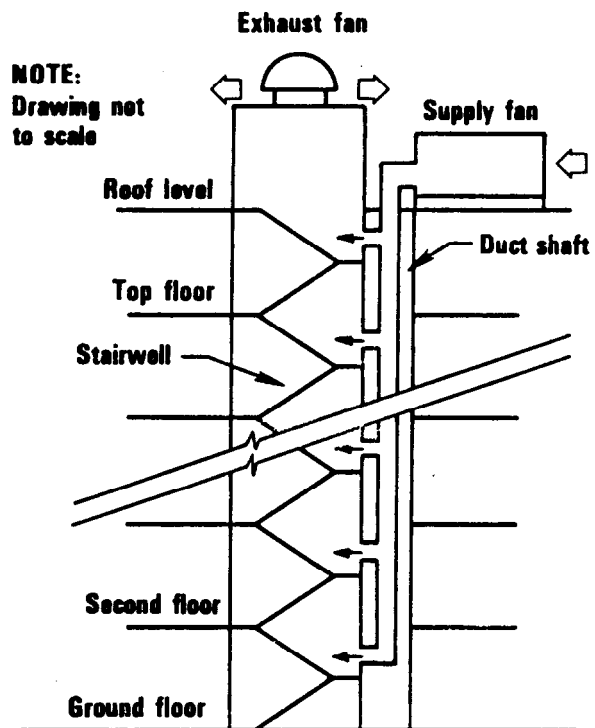


FIGURE 12-4
MULTIPLE INJECTION WITH AN EXHAUST FAN
AND A ROOF MOUNTED SUPPLY FAN

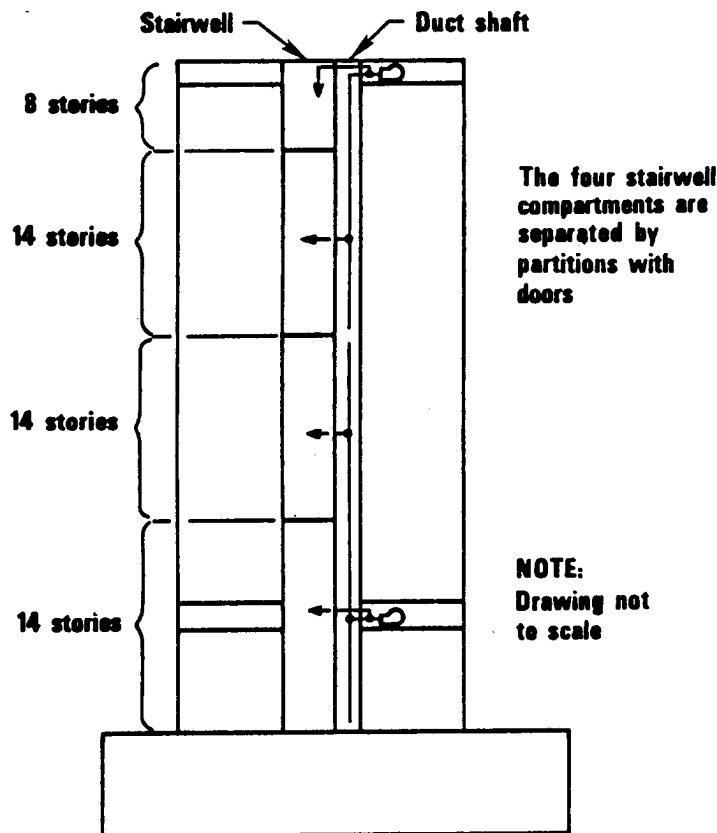


FIGURE 12-5
COMPARTMENTALIZATION OF STAIRWELL IN THE IDS CENTER IN MINNEAPOLIS

Major variables affecting the performance of stairwell pressurization systems are the fan capacity and the stairwell enclosure itself. The design is based on the fan performing at the rated capacity. Stairwell pressurization systems are most effective when air leakage paths are kept to a minimum, especially air leakage paths connecting to other parts of the building (as opposed to the outside). Possible air leakage paths include holes in the stairwell wall, open doors, and cracks under door.

Activation of a stairwell pressurization system can be accomplished as with other auxiliary functions, previously discussed in Chapter 2. This includes activation by manual pull boxes or automatic fire alarm initiating devices, such as heat and smoke detectors, water flow switches, etc.

12.2.2 Zoned Smoke Control Systems. Zoned smoke control systems operate by creating a slight negative pressure in the fire zone while providing a slight positive pressure in adjacent zones. A smoke control zone can consist of all or part of a floor level or several floors levels. The negative and positive pressures are created by the start-up and shutdown of selected fans in addition to the opening and closing of appropriate dampers. The fans utilized to create the pressure differences may be used only for smoke control or may be the same as those used for heating, ventilating and air conditioning purposes.

As with pressurized stairwell systems, zoned smoke control systems require a complete enclosure around the zone to be effective. This may require the use of smoke doors and dampers to properly restrict air flow through openings in the enclosure walls.

Zoned smoke control systems are also activated as an auxiliary function of an alarm system. However, activation by manual pull stations is generally not recommended since a manual pull station remote from the fire zone could be actuated to erroneously identify the "fire zone", resulting in inappropriate, and possibly damaging system operation.

12.2.3 Testing and Maintenance. All fans and dampers for the smoke control systems should be maintained in accordance with the manufacturer's recommendations, at least on a semi-annual basis. If changes have been made since the last inspection, fans, dampers, control devices and operating sequences should be checked by a complete operational test.

Annually, each smoke control system device should be activated by actuating an automatic fire alarm device. The fan and general smoke control system operation (especially dampers) should be checked. Inspection of the operation of smoke dampers should include verification of movement of the damper to the appropriate position as well as operation of the associated motor. The adequacy of the power supplies should be checked as for fire alarm systems, described previously in Chapter 3.

12.3 FIRE RESISTANT ASSEMBLIES.

12.3.1 Protection of Single Structural Members. Structural steel columns, beams and trusses may be individually protected. The typical means of protection includes installing a layer of a non-combustible, insulating material, as depicted in Figure 12-6.

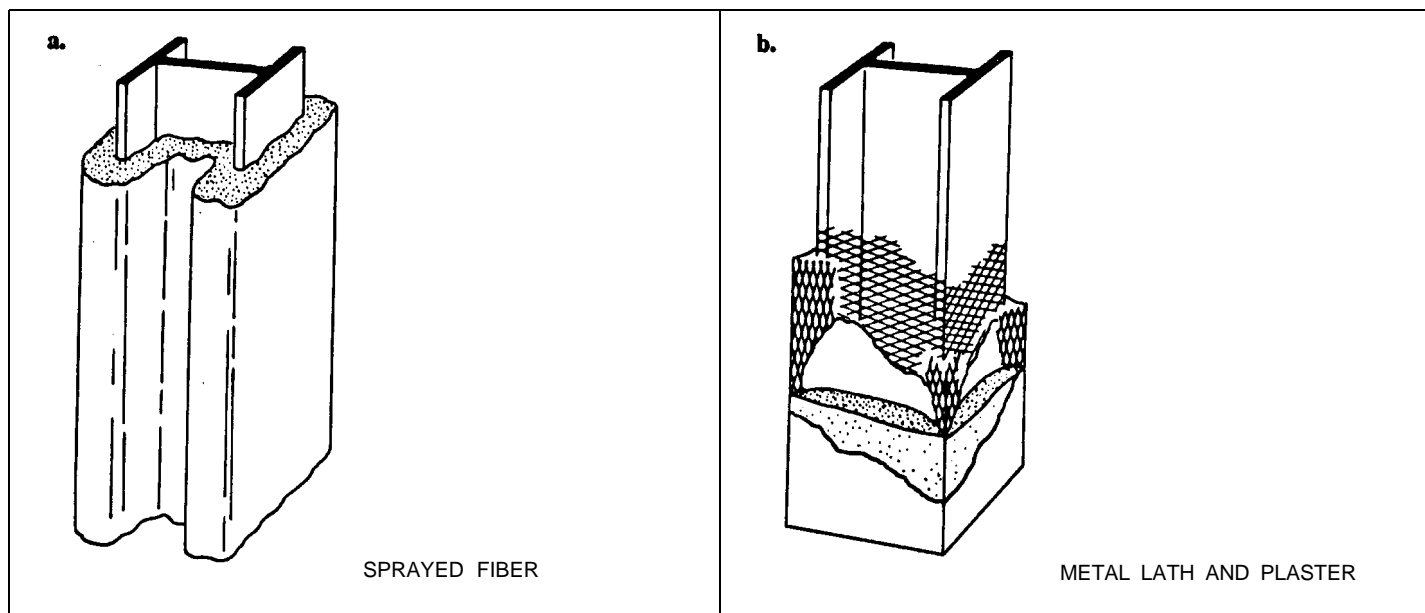


FIGURE 12-6
FIRE PROTECTION FOR STEEL COLUMNS

Over time, the protection material may be removed from physical contact or deterioration to expose the steel member. Inspection of the fire protection material is only involved with noting those locations where the material has

been removed, especially to the degree of exposing the steel. If some material has been removed, replacement of the material should be done only by a qualified contractor.

12.3.2 Fire Walls. Typically, the fire resistance rating of walls and other barriers, such as floor-ceiling assemblies is assigned after conducting a test on a prototype of the design. Following installation in an actual building, the wall may be altered as the building is modified. Such alterations may include making holes in the wall to permit ducts, pipes, and conduits to go from one side of the wall to the other. It is very important that the holes are filled-in by non-combustible insulating materials around the duct, pipe, or conduit. Inspection of a fire-rated wall should concentrate on noticing any unfilled poke-through holes.

12.3.3 Fire Doors. The purpose of a fire door is to remain closed in a fire-rated wall during a fire to restrict fire spread. Thus, an inspection and maintenance program should focus on proper operation of the door to permit it to close and latch (where appropriate).

Inspection of a fire door on an annual basis should include the following:

- examine hardware for proper operation (latch, knob, panic bar, etc.)
- look for signs of dry-rotting on those types of doors which are susceptible.
- check for excessive wear and/or stretching on chains or cables on suspended fire doors.
- observe if the door closes completely (as opposed to being blocked in the slightly open position).

Maintenance of doors should include the following:

- lubricate guides and bearings, as needed.
- check for proper latching and make necessary adjustments of chains or cables on sliding, counter balanced doors.
- check held-open. devices annually for proper operation during a fire alarm system test or test of detector at door (fusible links need not be actuated.)
- replace fusible links or other heat actuated devices which have been painted.

12.3.4 Fire Dampers. Fire dampers are installed in ventilation ducts where ducts penetrate fire-rated barriers, unless the building is equipped with a zoned smoke control system. In general, fire dampers require little maintenance. Damper and associated motors (where applicable) should be checked annually for proper operation. If fusible links are used to hold open the damper, the link should be removed to permit the proper operation of damper closure. Hinges, latches and other moving parts should be carefully examined **to** insure that the damper operates properly and lubricated if needed.

CHAPTER 12. SELF STUDY QUESTIONS

Instructions: Select the correct answer(s) for each of the following questions,

Q12-1 Single injection systems have a fan at each floor level of the stairwell.

- a. True
- b. False

Q12-2 Typical air leakage paths affecting stairwell pressurization system performance include:

- a. Holes in stairwell wall
- b. Open doors
- c. Cracks under door
- d. All of the above

Q12-3 Fans in zoned smoke control systems may be those used in the heating system.

- a. True
- b. False

Q12-4 Inspection of smoke dampers should include:

- a. Movement of damper
- b. Dust on damper vanes
- c. Actuation of fusible link
- d. None of the above

Q12-5 Fire walls require no special maintenance provisions.

- a. True
- b. False

Q12-6 Annual inspections of fire doors concentrate on the general operating characteristics of the door.

- a. True
- b. False

ANSWER KEY

UNIT 1

1-1. E
1-2. B
1-3. A
1-4. B
1-5. B
1-6. A
1-7. C
1-8. A

UNIT 2

2-1. c
2-2. D
2-3. A
2-4. A
2-5. D
2-6. C
2-7. B
2-8. A
2-9. C
2-10. B
2-11. D
2-12. C
2-13. D
2-14. B
2-15. A
2-16. C
2-17. D
2-18. D
2-19. B
2-20. A
2-21. C
2-22. C
2-23. B
2-24. B
2-25. D
2-26. A
2-27. D
2-28. A
2-29. B
2-30. D
2-31. D
2-32. C
2-33. C
2-34. C
2-35. B
2-36. A
2-37. A
2-38. B
2-39. C
2-40. B

UNIT 3

3-1. B
3-2. D
3-3. B
3-4. D
3-5. A
3-6. D
3-7. D
3-8. D
3-9. A
3-10. D
3-11. c
3-12. C
3-13. c
3-14. D
3-15. A
3-16. C
3-17. B
3-18. D
3-19. A
3-20. A
3-21. D
3-22. D
3-23. D
3-24. B
3-25. C
3-26. D
3-27. B
3-28. D
3-29. D
3-30. A
3-31. C
3-32. B
3-33. A
3-34. c
3-35. B
3-36. D
3-37. B
3-38. A
3-39. D
3-40. C
3-41. C
3-42. B
3-43. B
3-44. A
3-45. D
3-46. D
3-47. C

UNIT 4

4-1. A,B,E
4-2. A
4-3. D
4-4. A,B
4-5. C
4-6. B
4-7. A
4-8. C
4-9. A
4-10. A
4-11. B
4-12. B
4-13. B
4-14. B
4-15. A
4-16. B
4-17. A
4-18. A
4-19. B
4-20. A
4-21. B
4-22. A
4-23. C
4-24. A
4-25. C
4-26. B
4-27. A
4-28. B
4-29. B
4-30. B
4-31. A
4-32. D
4-33. A
4-34. A
4-35. C
4-36. D
4-37. B
4-38. C

UNIT 5

5-1. D
5-2. C
5-3. D
5-4. B
5-5. A,C
5-6. A
5-7. B
5-8. D
5-9. C,D
5-10. B

UNIT 5

5-11. A
5-12. B
5-13. B
5-14. A
5-15. B
5-16. D
5-17. B
5-18. B,C,D
5-19. A
5-20. A
5-21. B
5-22. A,D
5-23. B
5-24. D
5-25. B
5-26. A,C,D
5-27. C
5-28. A
5-29. A
5-30. A
5-31. C
5-32. A
5-33. B
5-34. B

UNIT 6

6-1. C
6-2. A
6-3. B,D
6-4. B
6-5. D
6-6. C
6-7. D
6-8. B

UNIT 7

7-1. C
7-2. D
7-3. A

UNIT 8

8-1. B
8-2. D
8-3. C
8-4. C
8-5. A
8-6. A
8-7. B

8-8. C
8-9. D
8-10. B
8-11. D
8-12. C

UNIT 9

9-1. B
9-2. B
9-3. A
9-4. A
9-5. C

UNIT 10

10-1. B
10-2. B
10-3. A,C
10-4. B
10-5. B

UNIT 11

11-1. A
11-2. D
11-3. A
11-4. B
11-5. A
11-6. B

UNIT 12

12-1. B
12-2. D
12-3. A
12-4. A
12-5. B
12-6. A

GLOSSARY

Accelerator	A device which speeds the operation of a dry pipe valve by channeling air, or nitrogen, from the sprinkler system piping to the intermediate chamber of the dry pipe valve.
Air Handling Unit (AHU)	The equipment which contains a fan or fans for moving air through a building which has a forced air ventilating system. Fans may be shut down by the fire alarm system during an alarm.
Air Maintenance Device	A device used to constantly maintain a specified air pressure in a dry pipe sprinkler system.
Alpha-Numeric Display	A type of display, often used at an alarm receiver console, which uses alphabetic characters (letters) and numbers to convey information.
Altitude Valve	A valve actuated (opened) by pressure loss usually due to the height of liquid in a tank.
Ambient Temperature	Temperature of the surrounding atmosphere.
Ammeter	An instrument for measuring the flow of electrical current.
Approved Equipment	Equipment which has been accepted by the authority having jurisdiction. One frequent criterion for approval is that the equipment must be listed by Underwriters' Laboratories (UL) or approved by Factory Mutual (FM).
Aspiration	The process of introducing a liquid or gas into a flowing stream by suction.
Automatic Fire Alarm System	A system using fire detectors, such as heat, smoke, systems and flame detectors to automatically initiate alarms.
Auxiliarized Alarm System	A building alarm system connected to transmit fire systems alarm signals to the base alarm headquarters through a municipal type base alarm system.

Backflow Preventer	See Check Valve.
Bonnet	The upper part of a fire hydrant which may be removed for maintenance of the operating stem.
Bowl Assembly	The vertical pipe extending down into the water supply which contains the impellers of a vertical turbine fire pump.
Butterfly Valve	A device which regulates the flow of a liquid by a plate which pivots in the waterway.
Carbon Dioxide (CO ₂)	A gas used for fire extinguishment purposes.
Cathode Ray Tube (CRT)	A vacuum tube in which a hot cathode emits electrons that are accelerated as a beam through a high voltage anode, focused or deflected electrostatically or electromagnetically and allowed to fall on a fluorescent screen. Often used as a display or readout device for computers and similar applications .
Check Valve	A device which permits a liquid or gas to flow in one direction only.
Circuit	Any path capable of being followed by an electric current.
Clapper	The device inside of a water control valve which prevents water downstream of the valve from entering the upstream side.
Coder	Coding mechanism connected to ring bells in a distinctive pattern or to transmit a pulsating signal to a remote receiver. The pattern of pulses may give location or may instead identify type of detection device (waterflow, heat detector, manual) generating the signal. The coder may operate by mechanically opening and closing electrical contacts or electronic circuitry may cause relay contacts to generate the code.
Combustible	A material which is capable of being ignited or burned.
Command Functions	Ability of an alarm system to control some functions of other building systems. For instance, when an alarm occurs, the alarm system may "command" fans to shut down or fire doors to close.
Conduit	Tubing, usually metal or plastic, which protects wiring from damage.

Contactor	An electrical device similar to a relay used for controlling heavy electrical equipment remotely. A contactor contains a coil and usually several sets of contacts for switching power on or off in response to energizing or deenergizing the coil.
Contacts	Metallic surfaces usually made of precious metal or plated with precious metal used for switching electrical current off and on in relays, con-tactors, and in switches. Contacts are used in sets or pairs. Two contacts are required to open or close an electrical circuit.
Continuity	An electrical condition in which there is no interruption between two points. Continuity is usually checked with an ohmmeter or the resistance measuring scale of a multimeter. If there is continuity, the resistance measured is less than infinite.
Control Valve	A valve which permits the regulation of a certain piece of equipment, e.g. , sprinkler riser control valve.
Convection	The motion of air caused by the variation in density of air with temperature. Heated air rises because it is less dense (lighter) than cooler air around it.
Current	A flow of electric charge. The amount of electric charge flowing past a point per unit time measured in amperes.
Dashpot	A damping device, used to delay movement. A piston moves in a cylinder and a trapped liquid or gas is allowed to leave the trapped space at a controlled rate through a hole in the piston or by another route. An air dashpot is frequently used in water-flow detection devices to delay the signal and eliminate false signals due to water pressure surges.
Data Gathering Panel (DGP)	Equipment used in multiplex systems as the connecting point for initiating circuits and other building alarm equipment. The DGP communicates with the main alarm console by transmitting status information when interrogated. Also known as interface panel.
Reenergize	The removal of electrical power from an electrically operated device such as a relay or contactor.

Deflection	Movement from a normal position. When applied to the indicator needle of a meter, it means the movement of the needle from its normal position.
Deluge System	A sprinkler system in which water discharges from open sprinklers at the same time.
Detector Check Valve	A device which measures incidental flows of water to a fire protection system and prevents reverse flows. Large flows are unmetered.
Diagnosis	Analysis of physical or electrical symptoms to determine condition.
Diaphragm Valve	A valve which is operated by pressure on one side of a membrane, or diaphragm, inside the valve and restricts flow through the valve in relationship to the pressure applied.
Dielectric	A nonconductor of electricity; an insulator or insulating material.
Diode	An electric device that restricts current flow chiefly to one direction, usually a semiconductor device.
Dispatcher	One who dispatches or sends out vehicles; especially one who dispatches fire trucks to the scene of a fire.
Display	Usually an arrangement of numbers and/or alphabetic characters which are selectively visible in accordance with coded electrical information received. A slide display makes use of photo- graphically prepared slides to project diagrams, maps and other information.
Door Closer	A device used, often electromagnetic, to close a door for the purpose of limiting the spread of smoke or fire in a building. The device may be activated by the fire alarm system.
Downstream	In the direction to which the water is flowing.
Dry Barrel Fire Hydrant	A fire hydrant which is controlled by a valve hydrant located at the base of the hydrant below the frost line.
Dry Circuit	A circuit powered by low DC voltage, frequently characterized by switch contact resistance problems.

Dry Pipe System	A sprinkler system which contains pressurized air or nitrogen instead of water. Water discharges through automatic sprinklers after operation of a dry pipe valve.
Eductor	A device used to introduce foam liquid concentrate into a water stream by venturi action.
Electrically Distant	Refers to devices nearer to the end of the circuit or remote than other devices. Such devices may be physically located near the circuit source.
Electromagnetic	Refers to devices containing an electromagnet consisting of a soft iron core wound with a current carrying coil of insulated wire. The current in the wire produces the magnetization of the core.
Energize	Apply electrical power to an electrically operated device such as a relay or contactor.
Equalize Charging	An intentional overcharge to equalize the charge level of the individual cells in a battery by assuring that each is fully charged. Any cells with a full charge produce gas while other cells continue to charge.
Evacuation Alarm	An alarm to warn occupants of an area to leave the area.
Exhauster	A device which speeds the operation of a dry pipe valve by allowing a larger volume of air to escape through itself than could escape through an open sprinkler.
Expellent Gas	A pressurized gas, usually nitrogen, which is used to agitate and permeate dry chemical to make it fluid so that it may be discharged from its storage container.
False Alarm	There are three types of false alarms: <ol style="list-style-type: none"> 1) System Malfunction - An alarm produced by an electrical malfunction of the alarm system. 2) Unintentional Alarm - An alarm that is inadvertently triggered. 3) Intentional Alarm - An alarm that is triggered by someone with malicious intent.
Fan Shutdown	A stoppage of the fans in an air handling unit (AHU) caused by a fire alarm system.

Fault	An electrical defect in a circuit of an alarm system.
Field of View	The region of space which is observable by an optical device, especially a flame detector.
Filtering	Removing unwanted electrical signals by using an electrical or electronic filter.
Fire Department Connection	A connection through which the fire department can connection pump water into a sprinkler or standpipe system.
Fire Classifications	Class A - Fires involving ordinary combustibles, such as wood, paper, cloth, rubber, plastics, etc.
	Class B - Fires involving flammable or combustible liquids, gases, greases, etc.
	Class C - Fires involving live electrical equipment.
	Class D - Fires involving certain combustible metals, such as magnesium, titanium, zirconium, sodium, potassium, etc.
Fire Door	A door intended to resist the progress of a fire.
Fire Flow Demand	The total quantity of water needed to supply sprinklers , standpipes and outside hydrants in a fire situation.
Float Valve	A valve which is actuated by a float and system of levers.
Foam Maker	A device designed to introduce air into a pressurized foam solution stream.
Gate Valve	A device which regulates the flow of a liquid or gas by raising or lowering a plate into the pipeway.
General Alarm	An alarm sounded throughout a building, as distinguished from an alarm sounded only in an administrative office or other limited area.
Ground	A conducting connection to the earth or to a portion of an electric circuit that is at zero potential with respect to the earth.
Halon	A term used to describe any one of several halogen-ated gaseous compounds. The term is followed by a four or five digit number to identify a specific gas.

Hose Header	A device used for testing fire pumps which consists of a manifold of two or more, depending on the size of the pump, 2-1/2 inch hose valves to which hoses with nozzles are attached. Various flow rates are achieved by opening the valves of the individual hoses.
Impeller	The rotating part in a fire pump which increases the water supply pressure by centrifugal force.
Indicating Device	A device which indicates an alarm, supervisory or trouble condition. Frequently, audible and visual devices such as bells, horns, lamps and flashing lights are used as indicating devices.
Initiating Devices	A device used to initiate the sequence of electrical events which results in a fire alarm or supervisory signal.
Inspection	Visual and mechanical checking of the condition of facilities, performed on a regularly scheduled basis, to determine the extent of the maintenance and repair work required and to ensure the proper operation of the systems.
Intermediate Chamber	A portion of a differential dry pipe valve which is below the clapper (water side) and is at atmospheric air pressure when the dry pipe valve is "set" for operation.
Ionize	To convert totally or partially into ions (charged particles). This principle is used in some smoke detectors.
Interface	Equipment which provides terminals for interconnecting two different systems, such as for interconnecting a building fire alarm system to the base alarm system.
Junction Box	A box containing provisions for making electrical circuit connections.
Line Voltage	The voltage supplied by ordinary commercial sources, normally 115 to 125 VAC.
Listed by UL	Equipment and devices which have been found by Underwriters' Laboratories, Inc., through testing of samples, to comply with applicable UL standards.
Local Energy	Term used to describe one method of tripping a municipal transmitting device. The power source for energizing the transmitter trip coil is a part of the local (building) alarm system.

Maintenance	Day-to-day, periodic, or scheduled work required to preserve or restore a facility or equipment to a condition that it can be effectively utilized for its designed purpose. It includes work to prevent damage or the deterioration of a facility that otherwise would be more costly to restore.
Master Box	A municipal fire alarm box which may be tripped manually at the box or remotely by electrical means.
Matrix	A rectangular array of indicators, usually lamps or LEDs, for identification of zone status in larger alarm systems.
Miscible	Capable of being mixed in all proportions.
Module	A self-contained assembly of electronic components and circuitry that performs certain functions in an alarm system. The module usually plugs into a larger rack or cabinet assembly.
Municipal Fire Alarm	A specially manufactured enclosure housing a box transmitting device, intended for connection to a municipal alarm system, that can be operated manually.
Municipal Transmitter	A device, which forms coded electrical signals, intended for connection to a municipal alarm system. The device can only be tripped remotely by electrical means.
Obscure	Obstruct or hinder the normal passage of light from its source to a light receiver.
Ohmmeter	An instrument for measuring resistance to the flow of electrical current.
Oleophobic	Oil hating; having the ability to shed gasoline, oil, and similar products.
Open Circuit	A circuit which has been broken by opening a switch or breaking a wire.
Operator	Person who operates alarm and communications equipment at an alarm system receiving installation.
Pinion	A small cogwheel or gear that engages, or is engaged by, a larger gear or a rack.
Pitot Tube	An instrument for measuring velocity pressure in flowing water.
Plant	One or more buildings under the same ownership or control on a single property.

Playpipe	A nozzle which is used primarily for fire pump testing. The standard playpipe has a 30 inch barrel with a 1-3/4 inch opening and provision for a screw-on 1-1/8 inch tip. A short playpipe has a 15 inch barrel. Both playpipes have swivel handles to provide a handgrip for two persons.
Pneumatic	Pertaining to air or other gases.
Polar Solvent	A liquid whose molecules possess a permanent electric moment. Examples are amines, esters, ethers, alcohols, aldehydes, and ketones. In firefighting, any flammable liquid which destroys regular foam is generally referred to as polar solvent.
Polarity	The possession of two opposing qualities. The plus and minus polarity of a battery or power supply .
Polarized	Having polarity.
Poppet	A piston-like device which acts as a valve to stop waterflow.
Potable	Acceptable for human consumption.
Power Disconnect	A switch for disconnecting and reconnecting electrical power to a circuit. The switch housing also usually contains circuit protective devices such as fuses or circuit breakers.
Pre-Action System	A sprinkler system in which the water control valve is operated independently from the sprinklers. Water discharges only from those sprinklers which have operated.
Pre-Prime Caps	Small caps placed over the orifices of open sprinklers or nozzles to permit the piping to be filled with water.
Priming Water	A small amount of water which is added to a dry pipe valve, downstream of the clapper, to provide a tight seal.
Print-Out	The printed output of a computer or computerized alarm system receiver.
Proportioning	The action by which foam liquid and water are mixed to form foam solution.
Public (or Base) Water	General term used to describe potable water.

Rectified	Converted from alternating current (AC) to direct current (DC).
Redundant	Duplicate or extra. Used in referring to duplicate equipment to provide continued function in case of failure in one set of equipment.
Regulated	Processed for constant and precise output.
Repair	Restoration of a facility or equipment to a condition that allows it to be used for its designed purpose. Repair may require overhaul, reprocessing, or replacing parts or materials that have deteriorated because of use or time.
Retard	An assembly used to delay the switch action of a waterflow detector and avoid false alarms.
Retard Chamber	A mechanical device which acts as a time delay in sounding an alarm upon flow of water in a sprinkler system. The device consists of a hollow chamber which must fill with water, from the sprinkler system, before actuating the alarm device.
Right Angle Gear Drive	A mechanism for transmitting power from a horizontally mounted pump driver (usually an engine) to a vertical shaft fire pump.
Saponification	The alkaline hydrolysis of fats to make soap.
Shunt Trip	Term used to describe the method of tripping a municipal transmitting device in which elements of a building alarm system are connected in parallel (shunt) with the transmitter trip coil. Removal of the shunt by the occurrence of an alarm in the building system causes the trip coil to energize and the transmitter to run. The trip coil is energized by the municipal system power source, not the building system.
Siamese Connection	See Fire Department Connection.
Sill Cock	A garden hose type faucet.
Slide Display	See Display.
Solenoid	An electromagnetic device in which electric current in a coil of wire causes mechanical movement of a metal core. Solenoids are sometimes used to actuate valves and dampers in a building fire protection system.

Solenoid Valve	A valve actuated by a solenoid.
Solid State	Related to the technology of semiconductors which led to the development of transistors, diodes, light emitting diodes (LEDs), and other devices.
Sprinkler	A device to distribute water upon a fire.
Sprinkler Riser	The portion of a sprinkler system which contains the system water control valves.
Spurious Alarm	A false alarm, usually caused by a defect in the alarm system.
Squib	An explosive device.
Standby Battery	A battery used as a secondary power supply for operation of a set of fire alarm equipment. It is usually rechargeable and maintained fully charged by the alarm system power supply . The changeover from normal powered operation to battery powered operation is automatic in modern equipment.
Stepped Down	Refers to AC voltage reduced by the use of a (step down) transformer to a lower AC voltage.
Surfactant	A chemical which lowers the surface tension of a liquid.
Tamper Switch	A switch which causes a trouble or supervisory signal if an equipment cover is opened. The term is sometimes applied also to valve supervisory switches.
Transformer	A device used to transfer alternating current energy from one circuit to another. A transformer consists of a pair of inductively coupled coils of wire, wound on a laminated metal core.
Transponder	A receiver/transmitter activated for transmission by reception of a predetermined signal . "Transponder" is made up of parts of the words "transmitter" and "responder ."
Trouble Signal	A signal indicating an alarm system abnormal condition requiring correction for the alarm system to be fully operational with all features.
Trim	Accessory piping connected to sprinkler valves.
Tripping (Trip Test)	The operation of a dry pipe valve.

Venturi	A constricted portion of a pipe or tube which increases water velocity, thus momentarily reducing its pressure.
Voltage	Electrical potential difference, usually expressed in volts.
Volute	The spiral cavity formed by a fire pump casing surrounding the pump impeller.
Wet Barrel Fire	A fire hydrant which is sometimes used in local hydrantities where freezing weather does not occur. Waterflow is usually controlled by a compression type valve at each outlet, although some may have one valve in the bonnet which controls waterflow to all outlets.
Wet Pipe System	A sprinkler system which contains pressurized water at all times. Water discharges upon the operation of automatic sprinklers.
Zone	An area or division of a building protected by one fire alarm initiating circuit. Sometimes the area and the circuit are referred to interchangeably as the zone. The fire alarm initiating circuit may be connected to represent a certain group of initiating devices instead of a particular area or division of the building.

MAINTENANCE OF FIRE PROTECTION SYSTEMS

INDEX

(Numbers after entry refer to sections in text.)

A

Abort feature	9.3.3
AC/DC high speed motors	3.3.8.3
Accelerator, dry pipe system	4.1.2.2, Figure 4-13
Accuracy of meter	3.3.11
Activating base fire alarm system	2.2.2.5
Advantages/disadvantages carbon dioxide systems	8.2.3
Air check valves	4.1.2.2
Air Force	1.4.3
Air pressure	
Maintenance device	4.1.2.2, Figure 4-16
Specifications	Table 5-3
Supervisory devices	3.7.6
Air pressure indicators	3.7.6
Alarm	
Beacon	3.8
Bell, electric	4.1.4
Boxes	3.6.1, Figures 2-12, 3-12
Check valves	4.1.2, 5.7, Figures 4-9, 10
Connection	
Base	2.2.1.4
Bypassing	3.9.4
Console	2.3.2.1, Figure 2-4, 28
Control unit	2.2.2.1
Equipment	Table 3-1
Headquarters, base	3.9.1
Indicating devices	2.2.2.3, 3.8, Figures 2-29, 32
Indicators	3.8.1, 3.8.2
Initiating devices	3.6, 3.7
Lamps	3.8
Service, fire	2.2.3.2
Signaling, remote	2.2.3.6
Signals	2.2, 2.3
Systems	2, 3
Associated	6.4, 7.4, 8.4, 9.3, 10.2, 11.3
Base fire	2.3
Building	2.2, 3.4.1
Classification	2.2.1, 2.3.1
Fire	2, Figures 2-5
Inspection frequencies	Table 3-1
Restore operating condition	Table 2-1
Services	2.2.3
Test frequencies	Table 3-1

A (continued)

Alarm (continued)	
Telegraph type	2.3.2.1
Telephone type	2.3.1.1. , 2.3.1.2, 3.10.3.1, 3.10.3.4, 3.10.3.5
Transmitter	2.3.2.1, 3.4.1.6
Alarms	
Connection to fire	3.10.2
False	2.2.3.4
Local sprinkler system	4.1.4, Figure 4-28
Manual fire	3.6.1
Water motor	4.1.4, Figure 4-28
Alcohol type foam	6.1.1.1
Alerting devices	6.4.3, 8.4.3, 10.2.3
Alpha-numeric	
Paper tape recorder	2.2.1.2, 2.3.2.3, Figure 2-4
Printers	3.4.1.5
Altitude valves	4.3.6.2, 5.18.7.4, Figures 4-63, 64, Table 5-1
Ammeter checking method	Figure 3-3
Antifreeze	
Solutions	Table 4-2
Systems	4.1.2.3, Figure 4-18
Annunciation	2.2.1.1, Figure 2-1
Annunciators	2.2.2.3, 3.4.1.4, Figure 2-8
Appliances, audible signal	2.2.2.3, Figure 2-8
Application, local	8.1.1, 8.2.8, 10.1, Figures 8-9, 10-2
Aqueous film forming foam (AFFF)	6.1.1.1
Army	1.4.1
Around-the-pump proportioning	6.2.1.5, Figure 6-5
Arrangement	
Circuit	6.4.2, 8.4.2, 10.2.2
Aspirator type foam generator	6.3.2.1, Figure 6-11
Assembly	
Fire resistant	12.3
Foam chamber	6.2.2.1, Figure 6-11
Associated alarm systems	6.4, 7.4, 8.4, 9.3, 10.2, 11.3
Audible alarm	
Indicators	3.8.2
Signals	2.2, 2.3.2.3
Audible current cutoff/timer	3.4.1.1
Audible signal appliances	2.2.2.3
Automatic	
Altitude valves	4.3.6, 5.18.7.4, Figures 4-63, 64
Dialers	2.3.1.2
Fire alarm initiating devices	3.6.2, 3.7
Fire alarm service	2.2.3.2
Pressure regulating valves	4.3.6, Figures 4-62, 63, 64, 65, 66
Sprinkler systems	4.1, Tables 1-1, 2, 5-1
Sprinklers	4.1.1.1, 5.2, Table 5-2
Standpipe systems	4.2, 5.12, Table 5-1
Tape dialer	2.3.1.2

A (continued)

Automatic (continued)

Transfer	2.4.1.5
Auxiliary	
Air check valves	4.1.2.2
Devices, alarm system	2.2.2.5
Dry pipe valves	4.1.2.2
Units	3.5

B

Backflow preventor	4.3.5.3, 5.18.7.3, Figure 4-61
Balance pressure proportioned	6.2.1.4, Figure 6-4
Base alarm systems	2.2.1.4, 2.3, 3.9, 3.10
Base fire alarm system	2.2.2.5, 2.3
Base system water supply	4.3.1
Battery	Table 3-1
Battery charger	2.2.2.4, 2.3.2.5, Figure 2-9
Beacon, rotating evaluation alarm	3.8.1.3,
3.8.2.5,	3.8.2.6
Beam scale weighing device	9.1.1, Figure 9-1
Beam type photoelectric detector	3.6.3.3, 3.6.3.6, 3.6.3.7
Bell, electric	2.2.3.3, 4.1.4
Bells	3.8.2
Bi-metallic element	4.1.1.1, Figure 4-5
Blower type foam generator	6.3.2.2, Figure 6-12
Box, radio call	2.3.1.2, 2.3.2.3
Boxes, fire alarm	3.6.1.1, 3.6.1.2, Figures 2-12, 28, 3-12
Building alarm systems	2.2, 2.3.2.5, 3.4.1, 3.9, 3.10.1
Butterfly valve indicator	3.7.1.3, 3.7.1.5, 3.7.1.6, 4.3.4.2
Butterfly valve position switch	Figures 2-18, 19

C

Call box, radio	2.3.1.2, 2.3.2.3
Capacitors	3.3.3, Figure 3-1
Cartridge, dry chemical gas	10.1.1.1, Figure 10-5
Cathode ray tube (CRT)	2.2.1.2, 2.3.2.3, Figure 2-4
Cathodic protection equipment	5.18.4.7, Table 5-1
Carbon dioxide systems	8.2, 9.1, Figures 8-1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 9-1, Table 9-1
Central station alarm system	2.3.1
Coded	3.10.3.1, 3.10.4.2
Centrifugal pump	4.3.3, Figures 4-38, 43
Chamber assembly, foam	6.2.2.1, Figure 6-7
Charger, battery	2.2.2.4, 2.3.2.5, Figure 2-9
Check valve, detector	4.3.5.2, Figure 4-57, Table 5-1
Check valves	4.1.2.1, 4.3.5.1, 5.7, 5.8, 5.18.7.1, Figures 4-9, 10, 54, 55, 56, 57, Table 5-1
Checking method	
Ammeter	Figure 3-3

C (continued)

Checking method (continued)	
Capacitor	Figure 3-1
Diode bridge	Figure 3-2
Checks, mercury	4.1.2.4, Figure 4-23, Table 5-1
Chemical extinguishing systems	10, 11, Figure 10-1, 2, 3, 4, 5, 6, Table 11-1
Chimes	3.8.2.3, 3.8.2.6
Circuit	
Arrangement and function	6.4.2, 8.4.2, 10.2.2
Base alarm system	3.10.3
Breakers	3.3.6
Closed	3.5.3.4, 3.5.4.2, Figure 2-33
Coded	Figures 2-6, 7
Fan shutdown	Figure 2-10
Faults	3.5.3, 3.5.4, Figures 3-7, 8, 9, 10, 11
Indicating	2.4.1, 3.5.4, Figures 2-29, 32, 35
Initiating	2.2.2.2, 2.4.1, 3.5.3, Figures 2-24, 30, 33, 34, 3-10
McCulloh	2.4.1.2, 3.10.3.4, Figure 2-31
Open	3.5, Figures 3-9, 11
Remote signaling	2.4.1, Figure 2-26
Series	2.2.2.2, 2.4.1.3, 3.5.3.4, 3.5.4.2, Figures 2-33, 35, 3-11
Short	3.5.3, 3.5.4
Shunt	2.2.2.2, Figure 2-6
Supervised	2.4
Telephone line	2.3.1.1
Unsupervised	2.4.1.4, 3.5.3.3, 3.5.4.1, Figures 2-34 3-10
Circulation heating	4.3.2.2, Figures 4-35, 36
Circulation relief valve	4.3.3
Class A circuit faults	3.5.3.6, 3.5.4.4, Table 3-1
Class A supervision applications	2.4.1.2
Class B circuit faults	3.5.3.5, 3.5.4.3
Class B supervision applications	2.4.1.1
Classes, supervision	2.4.1
Classification	
Base fire alarm systems	2.3.1
Signal transmission method	2.3.1.2
Standpipe systems	4.2.1
Closed circuit	2.4.1.3, 3.5.3.4, 3.5.4.2, Figure 3-11
Closing valves, emergency	5.14
Closure, fire door	2.2.2.5, 12.3.3
Coded alarm system	2.2.1.2, 2.2.2.2, 2.3.1.1, 3.4.1.3, 3.4.1.6, 3.6.1.2, Figures 2-6, 7, 3-4, 5, 12
Base alarm system	3.9.3, 3.10.3.2
Central station system	2.3.1.3, 3.10.3.1, 3.10.4
Selective	2.2.1.2
Transmitters	3.10.4
Coil, steam heating	4.3.2.2

C (continued)

Combination detectors	3.6.2.1
Combination UV/IR detectors	3.6.4.3, 3.6.4.4, 3.6.4.5
Combined sprinkler system	4.1.2.6, Figure 4-25
Combined standpipe system	4.2.2
Compartmentalized stairwells	12.2.1, Figure 12-5
Components	
Base alarm system	2.3.2
Building alarm system	2.2.2
Dry chemical extinguishing	10.1.2
Maintenance of common	3.3
Photoelectric smoke detector	Figure 3-17
Rate of rise detection	4.1.2.5, Figure 4-22
Concentrates, foam	6.1.1.1, 6.3.1, 7.3.1
Connections	
Base alarm	2.2.1.4
Building alarm	3.10
Fire department	4.3.1.2, 5.18.3, Figure 4-31
Foam discharge	Figure 6-10
Hose	5.12
Standpipe	5.12
Supervisory devices	3.10.2
Console, alarm	2.3.2.1, Figures 2-4, 28
Contact adjustment, McCulloh	Figure 3-4
Control panel switches	3.3.7
Control units	2.2.1.1, 2.2.2.1, 3.4.1, 3.5, Figures 2-1, 5
Control valves	4.3.4, 5.14, 5.18.6, 6, 7, Figures 4-51, 52, 53, Tables 5-1, 7-1
Controllers	4.3.3.3, Figure 4-50, Table 5-1
Converting sprinkler systems	5.16
Cooling water	4.3.3.3, Figure 4-48
Cooperation, services and departments	1.3
Coordination, Navy maintenance	1.4.2
Coordination, services and departments	1.3
Corrosion protection	4.3.2.3
Criteria, maintenance	1.5
Cross zoning	6.4, 7.4.2, 8.4, 9.3.2, Table 9-1
Current, operating	2.3.1.1
Current cutoff/timer	3.4.1.1

D

Dampers, fire	12.3.4
Data gathering panel	2.3.2.1, Figure 2-25
Data sheets, manufacturers	3.2
DC Motors	3.3.8.2
Deactivating sprinkler system	5.15
Deficiency detection, repair	1.6.3
Deflector, sprinkler styles	4.1.1.1, Figure 4-1

D (continued)

Deflection, obstruction of meter	3.3.11
Deflector	4.1.1.1
Deluge systems, water	4.1.2.4, Figure 4-19
Deluge valves	4.1.2.4, 4.1.2.7, 5.10, Figures 4-20, 21, 26, Table 5-1
Department connections, fire	4.3.1.2, 5.18.3, Figure 4-31
Detection	
Components, rate or rise	4.1.2.4, Figure 4-22
Deficiency, repair	1.6.3
Mechanical systems	4.1.2.4
Doors, fire	12.3.3
Detector check valve	4.3.5.2, Figure 4-57
Detector components, smoke	Figure 3-17
Detector power supply, smoke	2.2.2.4
Detectors	2.2.3, 3.6
Combination	3.6.2.1, 3.6.4.3
Dry pipe	3.6.5.6
Duct type	3.6.3.4, 3.6.3.5, 3.6.3.6, 3.6.3.7, Figure 3-19
Fixed temperature	3.6.2, Figures 3-13, 14, 15
Flame actuated	3.6.4
Heat	2.2.3.2, 3.6.2, 3.7.6, Figures 3-13, 14 15, 16
Infrared	2.2.3.2, 2.2.3.7, 3.6.4.1, 3.6.4.4, 3.6.4.5, Figure 3-20
Ionization smoke	3.6.3, Figure 3-18, 19
Line type	3.6.2.2
Photoelectric smoke	3.6.3, Figure 3-17
Rate compensated	3.6.2.1, Figure 3-16
Smoke	2.2.2.4, 2.2.3.2, 2.2.3.7, 3.6.3, Figure 3-17, 18, 19
Thermistor	3.6.2.1
Thermopile	3.6.2.1
Ultraviolet	2.2.3.2, 2.2.3.7, 3.6.4.2, 3.6.4.4, 3.6.4.5, Figure 3-21
UV\IR	3.6.4.3, 3.6.4.4, 3.6.4.5
Waterflow	3.6.5, Figures 3-22, 23, 24, 25
Devices	
Air pressure maintenance	4.1.2.2, Figure 4-16
Alarm indicating	2.2.2.3, 3.8
Alerting	6.4.3, 8.4.3, 10.2.3
Automatic initiating	3.6.2
Auxiliary alarm	2.2.2.5, 2.2.3.7
Beam scale weighing	9.1.1, Figure 9-1
Carbon dioxide operating	8.2.4
Dry chemical	10.1.2.1, 11.3.1
Indicating	2.2.3.5, 2.2.2.3
Initiating	2.2.2.2, 2.2.2.3, 3.6, 6.4.1, 8.4.1, 10.2.1
Pump	4.3.3
Release	7.3.1, 9.3.1

D (continued)

Devices (continued)

Signal	3.10.5, 3.10.6
Supervisory	3.7, Figure 3-28
Dialers, automatic	2.3.1.2
Diesel engine, fuel system	4.3.3.3, Figure 4-49
Differential dry pipe valve	4.1.2.2, Figures 4-12, 15, Table 5-3
Digital dialer	2.3.1.2
Diode bridge checking	3.3.4, Figure 3-2
Diodes	3.3.4
Direct-fired tank heaters	4.3.2.2
Disadvantages/advantages carbon dioxide system	8.2.3
Discharge of steam heating, direct	4.3.2.2
Displacement type meter	4.3.5.2, Figure 4-59
Displays, coded signal	2.2.1.2
Door holder	2.2.2.5, Figure 2-11
Double-acting altitude valves	4.3.6.2, Figure 4-63
Double check valves	4.3.5.1, Figure 4-56
Drill switch	2.2.2.1
Drivers for fire pump motors	4.3.3.3, Figures 4-45, 47
Dry barrel fire hydrant	4.3.1.1, 5-18.2, Figure 4-29
Dry chemical systems	10, 11, Figures 10-1, 2, 3, 4, 5, 6 Table 11-1
Dry pendant sprinkler	4.1.1.2, Figure 4-6
Dry pipe sprinkler system	4.1.2.2, 3.6.5.6, 3.7.6.1, 3.7.6.4, 3.7.6.5, Figures 4-13, 14
Dry pipe valves	4.1.2.2, 5.8, Figures 4-11, 12, 15, 17, Tables 5-1, 3
Dry standpipe systems	4.2.2
Duct type smoke detector	3.6.3.4, 3.6.3.5, 3.6.3.6, 3.6.3.7, Figure 3-19

E

Electric

Alarm bell	2.2.3.3, 4.1.4
Fire pump	3.7.3
Motor driven fire pump	4.3.3.3, Figure 4-45
Electrical	
Initiating devices	10.2.:
Release devices	7.4.1
Electromagnetic door holder	2.2.2 5, Figure 2-11
Electronic	
Level indicators	3.7.2 3, 3.7.2.4, 3.7.2.5
Pressure drop detector	3.6.5.5, 3.6.5.6, 3.6.5.7
Embankment supported water tanks	4.3.2.1, 5.18.4.4
Emergency, closing control valves	5.14
Emergency generators	Table 3-1
Engine	
Cooling	4.3.3.3, Figure 4-48
Driven fire pump	3.7.4, 4.3.3.3, Figure 4-47, 49, Table 5-1

E (continued)

Engine (continued)

Fire pump controller	4.3.3.3, Figure 4-50, Table 5-1
Malfunction indicator	3.7.4.3, 3.7.4.6, 3.7.4.7
Engineer, Army	1.4.1
Equipment	
Base alarm system	3.10
Cathodic protection	5.18.4.7
Explosion proof	6.4
Schematic diagrams	3.2
Typical maintenance for	3.4
Evacuation alarm	2.2.3.4
Beacons	3.8.1.3, 3.8.2.5, 3.8.2.6
Lamps	3.8.1.2, 3.8.2.5, 3.8.2.6
Evaluation, repair	1.6.3
Exhauster, dry pipe system	4.1.2.2, Figure 4-14
Explosive operated deluge valve	4.1.2.7, Figure 4-26
Extinguishing agent, release of	2.2.2.5, 2.2.3.7
Extinguishing systems	
Abort features	9.3.3
Associated alarm system	9.3, 10.2
Carbon dioxide	8.2, 9.1, Figure 8-1, 2, 3, 5, 6 7, 9-1, Table 9-1
Cross zoning	6.4, 7.3.2, 8.4, 9.3.2
Dry chemical	10, 11, Figures 10-1, 2, 4, 5, 6
Foam	6, 7.1, 7.2
Gaseous	8, 9, Table 9-1
Halon	8.3, 9.2, Figure 8-7
Local application	8.1.1, 8.2.8, 10.1, Figures 8-9, 10-2
Release devices	7.4.1, 9.3.1, 11.3.1
Wet chemical	10, 11, Figure 10-3

F

Fabric embankment water tanks	4.3.2.1, 5.18.4.4
Facilities, signal receiving	2.3.2.2
False alarm	2.2.3.4
Fans	12.2
Fan Shutdown	2.2.2.5, Figure 2-10
Fast response foam release	6.4
Faults	3.3, 3.4, 3.5, Figures 3-7, 8, 9, 10, 11
Filament lamps and LEDs	3.3.9.1
Finish, sprinkler frame	4.1.1.1
Fire	
Dampers	12.3.4
Department connections	4.3.1.2, 5.18.3, Figure 4-31
Doors	12.3.3
Door closure	2.2.2.5, 12.3.3
Hydrants	4.3.1.1, 5.18.2, Figures 4-29, 30
Loss statistics	1.9, Table 1-2

F (continued)

Fire (continued)

Pumps	3.7.3, 3.7.4, 4.3.3, 5.18.5, Figures 4-43, 44, 45, 46, 47, 49, 50, Tables 5-1, 4
Trouble signals	2.3.3.2, 3.6.5
Walls	12.3.2
Fire alarm	
Boxes	3.6.1.1, 3.6.1.2, Figures 2-12, 28, 3-12
Connection	3.10.2
Control unit	2.2.2.1, Figure 2-1
Initiating devices	3.6
Service, automatic	2.2.3.2
Service, manual	2.2.3.1
Transmitter	3.4.1.6
Systems	2, Figure 2-5
Fire alarms, manual	3.6.1
Fire department connection	4.3.1.2, 5.18.3, Figure 4-31, Table 5-1
Fixed temperature detectors	3.6.2, Figures 3-13, 14, 15, 16
Flame actuated detectors	3.6.4, Table 3-1
Flashing lamps	3.8.1.2, 3.8.2.5, 3.8.2.6
Float actuated level indicator	3.7.2.1, 3.7.2.4, 3.7.2.5
"Float" charges	2.3.2.5
Float valves	4.3.6.1, Figure 4-62
Flooding extinguishing systems	6.3, 8.1.2, 8.2.7, 10.1, Figures 8-8, 11, 10-1
Flow meters testing device	4.3.3, Figure 4-42
Fluoroprotein foam	6.1.1.1
Flushing	
Sprinkler systems	5.6
Water supplies	5.18.1
Foam	
Concentrate	7.3.1, Table 7-1
Quality	7.3, Table 7-1
Solution	7.3.2
Foam extinguishing systems	6, 7, Figures 6-1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12
Forced circulation heating	4.3.2.2, Figure 4-36
Frangible bulb sprinkler	4.1.1.1, Figure 4-3
Frangible pellet sprinkler	4.1.1.1, Figure 4-4
Frequency of inspection	3.5.1, 5.1, 7.1, 9.1, 11.1, Tables 3-1, 5-1, 7-1, 9-1, 11-1
Friction in meter	3.3.11
Fuel level indicator	3.7.4.5, 3.7.4.6, 3.7.4.7
Fuel system for diesel pump	4.3.3.3, Figure 4-49
Full registration meters	4.3.5.2, Figures 4-58, 59, 60
Function, circuit	6.4.2, 8.4.2, 10.2.2
Funds, availability of repair	1.6.3
Fuses	3.3.6
Fusible link sprinkler	4.1.1.1

G

Gas cartridge	10.1.1.1
Gaseous extinguishing systems	8, 9, Table 9-1
Gate valves	4.3.4, 5.18.6.1, Figures 2-23, 4-51, 52, 53
Generators, emergency	Table 3-1
Generators, high expansion foam	6.3.2, Figures 6-11, 12
Gong, water motor	2.2.3.3
Gravity circulation heating	4.3.2.2, Figure 4-35
Gravity steel tanks	4.3.2.1, 5.18.4.1
Gravity water tanks	4.3.2.1, 5.18.4, Figure 4-32
Ground fault	3.5, Figure 3-7

H

Halogenated gas extinguishing systems (Halon systems)	8.3, 9.2, Table 9-1
Hand-off-automatic (HOA) switch	3.7.4.4, 3.7.4.6, 3.7.4.7
Hangers	5.4
Hardware, dry and wet chemical systems	11.2
Hard-wired	2.3.1.2
Header arrangement	4.1.2.6, Figure 4-25
Heat actuated device (HAD)	4.1.2.4, Figure 4-23
Heat detectors	2.2.3.2, 3.6.2, 3.7.6, Figures 3-13, 14, 15, 16, Table 3-1
Heaters, tank	4.3.2.2
Heating methods	4.3.2.2, Figures 4-35, 36, 37
Heating systems, water tank	4.3.2.2, 5.18.4.6
High expansion foam systems	6.3, 7.2, Figures 6-11, 12
High pressure carbon dioxide systems	8.2.1, 8.2.3, 9.1.1, Figures 8-2, 9-1, Table 9-1
Horizontal split-case pump	4.3.3.1, Figures 4-38, 43
Horns	3.8.2.2, 3.8.2.5, 3.8.2.6
Hose	
Connections	5.12
Header testing	4.3.3
Line	8.1.3, 8.2.9, 9.1.1, 10.1, 11.2, Figures 8-10, 10-4, Tables 9-1, 11-1
Hydrants, fire	4.3.1.1, 5.18.2, Figures 4-29, 30, Table 5-1
Hydraulic flusing	5.6.1
Hydropneumatic flushing	5.6.2
Hydrostatic tests	9.1, 9.2, 11.2, Tables 9-1, 11-1

I

Indicating	
Circuit	2.4.1, 3.5.4, Figures 2-29, 32, 25
Circuit faults	3.5.4
Control valves	4.3.4.2
Devices, alarm	2.2.2.3, 2.2.3.5, 3.8

I (continued)

Indicator valves	4.3.4.2, Figures 4-52, 53
Indicators	
Air	3.7.6
Alarm, audible	3.8.2, Figure 2-8
Alarm visual	2.2.2.3, 3.3.9, 3.8.1
Annunciator	2.2.2.3
Engine malfunction	3.7.4.3, 3.7.4.6, 3.7.4.7
Hand-off-automatic (HOA)	3.7.4.4, 3.7.4.6, 3.7.4.7
Lamps, visual	3.3.9
Level	3.7.2, 3.7.4, Figure 3-28
Position	3.7.1, Figures 3-26, 27
Pump power failure	3.7.3.1, 3.7.4.1, 3.7.4.6, 3.7.4.7
Pump running	3.7.3.2, 3.7.4.2, 3.7.4.6, 3.7.4.7
Temperature	3.7.5
Infrared detectors	2.2.3.2, 2.2.3.7, 3.6.4.1, 3.6.4.4, 3.6.4.5, Figure 3-20
Initiating circuit faults	3.5.3
Initiating circuits	2.2.2.2, 2.4.1, Figures 2-24, 30, 33, 34 3-10, Table 3-1
Initiating devices	2.2.3
Associated systems	10.2.1
Circuits	2.2.2.2, Figures 2-24, 26, 29, 30, 31, 32, 33, 34, 35
Coded	2.2.2.2, Figures 2-6, 7
Fire alarm	3.6
Foam release	6.4.1
Gaseous systems	8.4.1
Noncoded	2.2.2.2
Inspection of	
Associated systems	7.3
Backflow preventer	5.18.7.3
Carbon dioxide systems	9.1, Figure 9-1, Table 9-1
Cathodic protection equipment	5.18.4.7
Control valves	5.18.6
Cross zoning	7.3.2, 9.3.2
Detectors	3.6
Dry chemical systems	11, Table 11-1
Fire dampers	12.3.4
Fire department connections	5.18.3
Fire doors	12.3.3
Fire hydrants	5.18.2
Fire walls	12.3.2
Foam systems	7, Table 7-1
Gaseous systems	9, Table 9-1
Halon systems	9.2, Table 9-1
Hangers	5.4
Heating systems	5.18.4.6
Hose connections	5.12
Meters	5.18.7.2
Piping	5.4, 5.5
Pump s	5.18.5.1, 5.18.5.2

I (continued)

Inspection of (continued)	
Release devices	7.3.1
Smoke control systems	12.2
Sprinklers	5.2, 5.3, 5.9, Table 5-1
Standpipe systems	5.12, Table 5-1
Suppression systems	5.11
Valves	5.7, 5.8, 5.10, 5.18.7.1, Table 5-1
Water mains	5.18.1, Table 5-1
Water tanks	5.18.4, Table 5-1
Inspections	
Maintenance, Navy	1.4.2
Maintenance, program	1.6.1
Installation of	
Carbon dioxide system	8.2.7, 8.2.8, 8.2.9, Figures 8-8, 9, 10
Dry chemical systems	10.1, Figures 10-1, 2
Flow meter	4.3.3, Figure 4-42
Proportioner	6.2, Figures 6-1, 2, 3, 4
Pump	4.3.3, Figures 4-38, 39
Switch	3.7.1.1, 3.7.1.2, Figures 3-26, 27
Water supervisory devices	3.7.2, Figure 3-28
Instructions, maintenance, Navy	1.4.2
Interlock to other building systems	2.2.3.7, 6.4.2, 8.4.2, 10.2.2
Internal combustion engine	4.3.3.3, Figure 4-50
Interruptions to systems	5.13
Ionization smoke detector	3.6.3, Figures 3-18, 19

J

Joint service responsibility	1.4
------------------------------	-----

K

Key-operated control valve	4.3.4.1, Figure 4-51
----------------------------	----------------------

L

Lamps	3.3.9
Filament	3.3.9.1
Flashing evacuation alarm	3.8.1.2, 3.8.2.5, 3.8.2.6
Neon	3.3.9.2
Sockets	3.3.9.4
Total assembly	3.3.9.3
Zone annunciator	3.8.1.1, 3.8.2.5, 3.8.2.6
Latched-clapper dry pipe valve	4.1.2.2, Figure 4-17
LEDs (light-emitting-diodes)	2.2.2.3, 3.3.9.1
Level indicators	3.7.2, 3.7.4.5, 3.7.4.6, 3.7.4.7, Figure 3-28
Level supervisory devices	3.7.2
Level switch, water	2.2.3.5, Figure 2-21
Light-emitting-diodes (LEDs)	2.2.2.3, 3.3.9.1

L (continued)

Line proportioning	6.2.1.1, Figure 6-1
Line type detectors	3.6.2.2
Line voltage control unit	3.4.1.1
Line voltage systems	2.2.1.3
Link, fusible	4.1.1.1
Local alarm system	2.2.1.4
Local alarm systems for sprinkler systems	4.1.4, Figure 4-28
Local application systems	8.1.1, 8.2.8, 10.1, Figures 8-9, 10-2
Loss, fire, statistics	1.9
Low back pressure foam makers	6.2.2.1
Low-differential valve	4.1.2.2, Figure 4-15
Low expansion foam systems	6.2, 7.1
Low pressure carbon dioxide	8.2.2, 8.2.3, 9.1.2, Figure 8-3, Table 9-1
Low temperature indicator	3.7.5
Low voltage control unit	3.4.1.2
Low voltage systems	2.2.1.3

M

Main drain test	Table 5-1
Maintenance	3, 5, 7, 9, 11
Abort feature	9.3.3
Alarm indicating device	3.8.2.5
Associated alarm systems	9.3, 11.3
Backflow preventer	5.18.7.3
Base alarm system circuits	3.10.3.4
Characteristic, typical	3.4
Components, common	3.3
Connections	5.12
Criteria	1.5
Detectors	3.6.2.1, 3.6.2.2, 3.6.3.6, 3.6.4.3, 3.6.5.6
Dry chemical systems	11, Table 11-1
Fire dampers	12.3.4
Fire doors	12.3.3
Fire hydrants	5.18.2
Fire pump supervisory devices	3.7.4.6
Fire walls	12.3.2
Foam systems	7.2, 7.3, 7.4.1, 7.4.2, Table 7-1
Gaseous systems	9, Figure 9-1, Table 9-1
Halon systems	9.2, Table 9-1
Hydrants	5.18.2
Importance of	1.9
Indicating devices	3.8.2.5
Manual fire alarms	3.6.1.3
Policies	1.5
Power supplies	3.10.7.1
Program	1.6
Navy	1.4.2
Reference materials	3.2

M (continued)

Maintenance (continued)

Signal receiving devices	3.10.5.1
Signal recording devices	3.10.6.1
Sprinkler systems, automatic	5, Table 5-1
Standards	1.5
Standpipe systems, automatic	5.12, Table 5-1
Supervisory devices	3.7
Suppression systems, high speed	5.11
Transmitters	3.10.4.6
Valves	
Altitude	5.18.7.4
Check	5.7, 5.8, 5.18.7.1
Control, sprinkler	5.18.6
Deluge	5.10
Gate, above ground	5.18.6.1
Pipe, dry	5.8
Pre-action	5.10
Water mains	5.18.1
Water tanks	5.18.4
Waterflow meters	5.18.7.2
Malfunction indicator, engine	3.7.4.3, 3.7.4.6, 3.7.4.7
Manual fire alarm service	2.2.3.1, Figure 2-12
Manual fire alarms	3.6.1, Figure 2-12, Table 3-1
Manufacturer's data sheets	3.2
March-time coded	2.2.1.2
Master coded	2.2.1.2
McCulloh devices	2.3.2, 2.4.1.2, 3.4.1.6, 3.10.3.4, Figures 2-27, 31, 3-4, 5, 6
Mechanical	
Detection systems	4.1.2.4
Dry pipe valve	4.1.2.2, Figure 4-17
Flushing	5.6.3
Mercury checks	4.1.2.4, Figure 4-23
Meter	3.3.11, 4.3.5.2, 5.18.7.2, Figures 4-42., 57, 58, 59, 60
Monitor-mounted foam nozzle	6.2.2.1, Figure 6-6
Monitoring signals	2.3.3
Motor	3.3.8, 4.3.3.3, Figures 4-45, 46
AC synchronous	3.3.8.4
Alarm, water	4.1.4, Figure 4-28
DC	3.3.8.2, 3.3.8.3
Gong, water	2.2.3.3, Figure 4-28
Pump, fire	4.3.3.3, Figure 4-45, 46, 47
Spring	3.3.8.1
Multiple annunciation	2.2.1.1
Multiplex	2.3.1.2, 2.3.2.3, 3.10.3, 3.10.4, Figure 2-25
Municipal base system, coded	3.10.3.2
Municipal type	
Alarm system	2.3.1.1, 2.3.1.2, 2.3.1.3

M (continued)

Municipal type (continued)	
Receivers	2.3.2.3
Transmitters, coded	3.10.4.3

N

National Fire Protection Association (NFPA)	1.9
Navy	1.4.2
Neon lamps	3.3.9.2
Noncoded	
Alarm circuit	2.3.1.1
Alarm system	2.2.1.1
Base alarm system	3.9.2
Fire alarm boxes	3.6.1.1
Initiating devices	2.2.2.2
Remote station	3.10.3.1
Transmitters	3.10.4.1, 3.10.4.6, 3.10.4.7
Nonindicating control valves,	4.3.4.1, Figure 4-51
Noninterfering initiating circuits	2.2.2.2
Notification equipment	1.2
Nozzle system	4.1.2.7, Figure 4-27
Nozzles	
Carbon dioxide	8.2.6, Figure 8-4, Table 9-1
Dry chemical	10.1.2.3, Table 11-1
Foam	6.2.2.1, Figure 6-5, Table 7-1
Halon	8.3.5, Figure 8-13, Table 9-1
Water spray	4.1.1.4, Figure 4-8

O

Obstructed piping	5.5
Obstruction of meter deflection	3.3.11
On-off sprinkler	4.1.1.1
Open circuit	3.5, Figures 3-9, 11
Open sprinklers	4.1.1.3, 5.3, Figure 4-7
Operating condition, restore	Table 2-1
Operating current	2.3.1.1
Operating devices	8.2.4, 8.3.3, 10.1.2.1
Operating voltage	2.2.1.3, 2.3.1.1
Orifice size	4.1.1.1
OSHA regulations	1.7
Outside open sprinklers	5.3
Outside screw and yoke valve (OS&Y)	3.7.1.1, 3.7.1.5, 3.7.1.6, 4.3.4.2, Figures 2-13, 14, 3-26, 4-53

P

Panel data gathering	2.3.2.1
Paper tape recorder	2.2.1.2, 3.4.1.5, Figures 2-3, 4
Pellet sprinkler, frangible	4.1.1.1, Figure 4-4

P (continued)

Performance summary, automatic sprinkler	Tables 1-1, 2
Performance testing of fire pumps	5.18.5.2
Photoelectric smoke detector	3.6.3
Pilot operated nozzle system	4.1.2.7, Figure 4-27
Pipe sprinkler system	4.1.2.1, 4.1.2.2, Figures 4-13, 14
Pipe valves	4.1.2.2, 5.8, Figures 4-11, 12, 15, 17, Table 5-3
Piping	4.1.3, 5.4, 5.5, 7.8.2.5, 8.3.4, 10.1.2.2, Table 7-1
Pitot tube	4.3.3, 5.18.1, Figure 4-41
PIV	3.7.1.2, 3.7.1.5, 3.7.1.6, 4.3.4.2, Figures 3-27, 4-52
PIV position switch	2.2.3.5, Figures 2-16, 17
Plant type wiring	3.10.3.2, 3.10.3.4, 3.10.3.5
Plastic sprinkler pipe	4.1.3
Plugs, pre-prime	4.1.2.4, Figure 4-24
Policies, maintenance	1.5
Policy, Air Force	1.4.3
Portable cylinder weighing device	9.1.1, Figure 9-1
Position indicator	3.7.1.2, 3.7.1.3, 3.7.1.5, 3.7.1.6, 3.7.4.4, 3.7.4.6, 3.7.4.7
Post indicator valves (PIV)	3.7.1.2, 3.7.1.5, 3.7.1.6, 4.3.4.2, Figures 3-27, 4-52
Power	2.3, 2.4
Circuit faults	3.5.3.1, 3.5.3.2, Figures 3-7, 8, 9
Failure indicator	3.7.3.1, 3.7.4.1, 3.7.4.6, 3.7.4.7
Secondary	2.3.2.5
Supervision applications	2.4.1.5, Figure 2-36
Supplies	2.2.2.4, 2.3.2.5, 3.10.7
Pre-action sprinkler system	4.1.2.5
Pre-action valves	4.1.2.5, 5.10, Table 5-1
Pre-prime plugs	4.1.2.4, Figure 4-24
Presignal alarm	2.2.2.3, 2.2.3.4
Pressure	
Backflow preventer, reduced	4.3.5.3, 5.18.7.3, Figure 4-61
Carbon dioxide cylinders	8.2, Figure 8-1
Detectors	3.6.5.1, 3.6.5.2, 3.6.5.4, 3.6.5.6, 3.6.5.7, Figure 3-22
Dry chemicals	10.1.1.2, Figure 10-6 -
Foam makers	6.2.2.1, 6.2.2.2, Figures 6-9, 10
Indicators	3.7.2.2, 3.7.2.4, 3.7.2.5, 3.7.6
Maintenance device	4.1.2.2, Figure 4-16
Proportioning, foam	6.2.1.2, 6.2.1.3, 6.2.1.4, Figures 6-2, 4
Regulating Valve	4.3.6, Figures 4-62, 63, 64, 65, 66, Table 5-1
Supervisory devices	3.7.6
Switches	2.2.3.3, Table 9-1
Valves	4.3.3, 4.3.6, 5.18.7.4, Figures 4-62, 63, 64, 65, 66, Table 5-3
Water tanks	4.3.2.1, 5.18.4.5, Figure 4-34

P (continued)

Pressurization, stairwell	12.2.1, Figures 12-1, 2, 3, 4, 5
Preventer, backflow	4.3.5.3, 5.18.7.3, Figure 4-61
Primary power	2.3.2.5
Printers	2.2.1.2, 3.4.1.5
Procedures	3.5
Program, maintenance	1.6, 1.4.2
Proportional type meter	4.3.5.2, Figure 4-58
Proportioner	
Around-the-pump	6.2.1.5, Figure 6-5, Table 7-1
Balanced pressure	6.2.1.4, Figure 6-4, Table 7-1
Proprietary base system	3.10.3.2, 3.10.3.4, 3.10.3.5
Proprietary type alarm system	2.3.1.1, 2.3.1.3
Protected power supplies	2.3.2.5
Protection, corrosion	4.3.2.3
Protection, equipment, cathodic	5.18.4.7
Protein foam	6.1.1.1
Public water supplies	4.3.1
Public Works	1.4.2
Pump	
Centrifugal	4.3.3, Figures 4-38, 43
Controller	4.3.3.3, Figure 4-50
Engine cooling	4.3.3.3, Figure 4-48
Engine driven fire	4.3.3.3, Figure 4-47
Foam	7, Table 7-1
Motor controller	4.3.3.3, Figure 4-46
Motors	4.3.3.3, Figures 4-45, 46
Power failure indicators	3.7.3.1, 3.7.4.1, 3.7.4.6, 3.7.4.7
Running indicator	3.7.3.2, 3.7.4.2, 3.7.4.6, 3.7.4.7
Supervisory devices	3.7.3, 3.7.4
Troubles	Table 5-4
Pumps	4.3.3, 5.18.5, 7, Figures 4-38, 39, 40, 42, 43, 44, 45, 47, 49, 50, Table 7-1

R

Radiator heating	4.3.2.2, Figure 4-37
Radio call box	2.3.1.2, 2.3.2.3, Figure 2-28
Radio frequency base system	2.3.2, 3.10.3.3, 3.10.3.4, 3.10.3.5, Figure 2-28
Radio frequency transmitters	3.10.4.5, 3.10.4.6, 3.10.4.7
Rapid reaction water suppression	4.1.2.7
Rate of rise detectors	3.6.2.1, 3.6.2.2, 4.1.2.4, Figures 3-15, 16, 4-22
Rating, temperature	4.1.1.1, Table 4-1
Receivers	2.3.2.3, 3.10.5, Figure 2-28
Receiving	
Devices, signal	3.10.5, Figure 2-27, Table 3-1
Facilities, signal	2.3.2.2
Station power supply	2.3.2.5

R (continued)

Recorders	2.2.1.2, 2.3.2.3, 2.3.2.4, 3.4.1.5, Figures 2-3, 4
Recording devices	3.10.6, Table 3-1
Reduced pressure backflow preventer	4.3.5.3, 5.18.7.3, Figure 4-61
Reducing valves, pressure	4.3.6.3, Figure 4-65
Reference materials, maintenance	3.2
Register	
McCulloh tape	2.3.2.4
Paper tape	3.4.1.5
Regulating valves	4.3.6, Figures 4-62, 63, 64, 65, 66
Residential sprinkler systems	4.1.2.8
Relay, trouble	2.4.1.1
Relays	3.3.1
Release devices	7.4.1, 9.3.1, 11.3.1
Release extinguishing agent	2.2.2.5, 2.2.3.7, 6.4, 8.4, 10.2
Relief valve	4.3.3, 4.3.6.4, Figures 4-42, 66
Remote	
Alarm signaling	2.2.3.6
Annunciation	2.2.1.1, Figure 2-2
Circuit, signaling	2.4.1.1, 2.4.1.2, Figures 2-26, 31
Receivers	2.3.2.3
Station alarm system	2.3.1.1, 2.3.1.3, 3.10.3.1, 3.10.3.4, 3.10.3.5
Transmitters	3.4.1.6
Repair	1.6.3
Replacement cost	1.6.3
Resistors	3.3.2
Responsibility, joint service	1.4
Rotating evacuation alarm beacons	3.8.1.3, 3.8.2.5, 3.8.2.6
Rubberized fabric water tank	4.3.2.1, 5.18.4.4
Running indicators, pump	3.7.3.2, 3.7.4.2, 3.7.4.6, 3.7.4.7

S

Safety	
Air Force	1.4.3
Army	1.7
Navy	1.4.2
Scale, beam	9.1.1, Figure 9-1
Schematic wiring diagrams	3.2
Screw and yoke valve, outside (OS&Y)	3.7.1.1, 3.7.1.5, 3.7.1.6, 4.3.4.2, Figures 2-13, 14, 3-26, 4-53
Secondary power	2.3.2.5
Selective coded alarm system	2.2.1.2
Series circuit	2.2.2.2, 2.4.1.3", 3.5X.4, 3.5.4.2, Figures 2-33, 35, 3-11
Service responsibility, joint	1.4
Services, fire alarm	2.2.3, 2.3.3
Short circuit faults	3.5.3.1, 3.5.4, Figures 3-8, 10
Short circuits	3.5.3, 3.5.4

S (continued)

Shunt circuits	2.2.2.2, Figure 2-6
Signal	
Appliances	2.2.2.3, Figure 2-8
Power supply	2.3.2.5
Receivers	2.3.2.3
Receiving devices	3.10.5
Receiving facilities	2.3.2.2, Figure 2-27
Recorders	2.2.1.2, 2.3.2.3, 2.3.2.4, 3.4.1.5, Figures 2-3, 4
Recording devices	3.10.6
Transmission	2.3.1.2
Transmitters	2.3.2.1, 3.4.1.6, 3.10.4
Signaling, remote alarm	2.2.3.6
Signaling circuit	2.4.1.1, 2.4.1.2, Figures 2-26, 31, Table 3-1
Signals	
Alarm	2.2, 2.3.2.3
Monitoring	2.3.3
Transmitted to headquarters	3.9.1
Trouble	2.3.2.5, 2.4.1.1, 2.4.1.2, 2.4.1.5
Single-acting altitude valve	4.3.6.2, Figure 4-64
Size, orifice, sprinkler	4.1.1.1
Smoke control	12.2, Figures 12-1, 2, 3, 4, 5
Smoke detectors	2.2.2.4, 2.2.3.2, 2.2.3.7, 3.6.3, Figures 3-17, 18, 19, Table 3-1
Sockets, lamp	3.3.9.4
Solutions, antifreeze	Table 4-2
Speakers	3.8.2.4, 3.8.2.5, 3.8.2.6
Specifications, dry pipe valve	Table 5-3
Spot type detectors	3.6.2.1, 3.6.3.1, 3.6.3.2, 3.6.3.6, 3.6.3.7, 3.6.4
Spray nozzles	4.1.1.4, Figure 4-8
Spring motors	3.3.8.1
Sprinkler	
Control valves	5.14, 5.15, 5.16, 5.18.6, Figures 4-12, 19, 51, 52, 53
Deflector styles	4.1.1.1, Figure 4-1
Frame finish	4.1.1.1
Inspection	5.2, 5.3, Table 5-1
Maintenance	5.2, 5.3
Pre-prime plugs	4.1.2.4, Figure 4-24
Pressure indicators	3.7.6.1
Supervisory alarm	2.2.3.5, 3.6.5, 3.7
Supervisory signals	2.3.3.3
Systems	4,5
Temperature ratings	Table 4-1
Waterflow detectors	3.6.5
Sprinklers,	4.1.1
Automatic	4.1.1.1
Bi-metallic element	4.1.1.1, Figure 4-5
Dry pendent	4.1.1.1, Figure 4-6

S (continued)

Sprinklers (continued)

Foam	6.2.2.1, Figure 6-8
Frangible bulb & pellet	4.1.1.1, Figures 4-3, 4
Fusible link	4.1.1.1
on-off	4.1.1.1
Open	4.1.1.3, Figure 4-7
Performance, summary	Tables 1-1, 2
Spare	Table 5-2
Testing	5.2, Table 5-1
Stairwell, compartmentalized	12.2.1, Figure 12-5
Stairwell pressurization systems	12.2.1, Figures 12-1, 2, 3, 4, 5
Bottom injection	12.2.1, Figure 12-1
Multiple injection	12.2.1, Figures 12-3, 4
Top injection	12.2.1, Figure 12-2
Standards	
Air Force	1.4.3
Maintenance	1.5
OSHA	1.7
Standpipe systems	1.2, 4.2, 4.3, 5.12, 5.13, 5.18, Table 5-1
Station	3.10.3.1, 3.10.3.4, 3.10.3.5
Central	2.3.1.3, 3.10.4.2
Power supply	2.3.2.5
Receivers	2.3.2.3
Remote	2.3.1.3
Transmitters	3.10.4.1, 3.10.4.6, 3.10.4.7
Steam heating	4.3.2.2, 5.18.4.6
Steel columns	Figure 12-6
Steel tanks	4.3.2.1, 5.18.4.1
Storage tank	4.3.2, 6.2, 8.2.2, Figures 4-32, 33, 34, 6-3, 8-3
Stored pressure	10.1.1.2, Figure 10-6
Structural members	12.3.1
Styles, deflector	Figure 4-1
Suction water tanks	4.3.2.1, 5.18.4.1, Figure 4-33
Supervised	
Circuits	2.4
Circuit faults	3.5.3.4
Supervision applications	2.4.1, Figure 2-36
Supervisory	
Alarm	2.2.3.5
Devices	3.7, 3.10.2 , Figures 2-21, 22, 3-28
Pressure switch	3.7.6
Signals	2.3.3.3
Switch installation	Figures 3-26, 27
Supplies	
Power	2.2.2.4, 2.3.2.5, 3.10.7
Water	4.3
Suppression system	5.11
Swing check valve	4.3.5.1, Figure 4-54

S (continued)

Switches	2.2.2.1, 2.2.3.3, 3.3.7, Figures 2-13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 3-26, 27
Synchronous AC motors	3.3.8.4

T

Tags	3.2
Tank heaters	4.3.2.2, 5.18.4.6
Tanks	
Bladder	Figure 6-3
Carbon dioxide storage	8.2.2, Figure 8-3
Cathodic protection equipment	5.18.4.7
Foam pressure proportioning	6.2.1.3
Pressure	4.3.2.1, 5.18.4.5
Water	4.3.2, 5.18.4, Figures 4-32, 33, 34, 35, 36, 37, Table 5-1
Tape recorder	2.2.1.2, 2.3.2.3, 3.4.1.5, Figure 2-3
Telegraph type alarm transmitter	2.3.2.1
Telephone type alarm	2.3.1.1, 2.3.1.2, 3.10.3.1, 3.10.3.4, 3.10.3.5
Temperature	
Detectors	3.6.2, Figures 3-14, 15
Indicators	3.7.5
Rating	4.1.1.1, Table 4-1
Supervisory devices	3.7.5, Figure 3-28
Switch	Figures 2-15, 22
Test	
Frequencies	Tables 3-1, 5-1, 7-1, 9-1, 11-1
McCulloh	2.4.1.2, 3.10.3.4, Figure 2-31
Procedure	3.5.2
Switches	2.2.2.1
Testing	3, 5, 7, 9, 11
Abort feature	9.3.3
Associated alarm systems	9.3, 11.3
Auxiliary units	3.5
Base alarm connections	3.9.4
Base alarm system circuits	3.10.3.4
Connections	5.12
Control units	3.5
Detectors	3.6.2.1, 3.6.2.2, 3.6.3.6, 3.6.4.4, 3.6.5.6
Dry chemical systems	11, Table 11-1
Fire hydrants	5.18.2
Flame detectors	3.6.4.4
Foam systems	7.1, 7.2, 7.3.1, 7.3.2, 9.3.2
Gaseous systems	9, Figure 9-1, Table 9-1
General procedures	3.5
Halogenated gas extinguishing systems	9.2, Figure 9-1, Table 9-1

T (continued)

Testing (continued)

Hangers	5.4
Hydrostatic	8.2.3.3
Indicating devices	3.8.2.5
Initiating devices	3.6.1.3, 3.7.1.5
Manual fire alarms	3.6.1.3
Piping	5.4, 5.5
Power supplies	3.10.7.1
Pumps	5.18.5.2
Release devices	9.3.1
Signal recording devices	3.10.6.1
Signal receiving devices	3.10.5.1
Smoke control systems	12.2.3
Smoke detectors	3.6.3.6
Sprinkler systems, automatic	5, Table 5-1
Standpipe systems, automatic	5, Table 5-1
Supervisory devices	3.7
Suppression system, high speed	5.11
Transmitters	3.10.4.6
Valves	
Altitude	5.18.7.4
Check	5.7, 5.8
Control	5.18.6
Deluge	5.10
Dry pipe	5.8
Pre-action	5.10
Waterflow detectors	3.6.5.6
Water mains	5.18.1
Water tanks	5.18.4
Testing devices for pumps	4.3.3, Figures 4-41, 42
Thermistor detectors	3.6.2.1
Thermopile detectors	3.6.2.1
Timer/current cutoff	3.4.1.1
Transfer, automatic	2.4.1.5
Transformers	3.3.5
Transmission	2.3.1.2
Transmitters	2.3.2.1, 3.4.1.6, 3.10.4, Table 3-1
Transponder	2.3.2.1
"Trickle charges"	2.3.2.5
Trouble	
Relay	2.4.1.1
Signal	2.3.2.5, 2.4.1.1, 2.4.1.2, 2.4.1.5
Troubles, fire pump	Table 5-4
Troubleshooting	3, 5, 7, 9, 11
Abort feature	9.3.3
Alarm indicating devices	3.8.2.6
Associated alarm systems	11.3.3
Circuit faults	3.5.3, Figures 3-7, 8, 9, 10, 11
Circuits	3.10.3.5
Cross zoning	7.4.2

T (continued)

Troubleshooting (continued)

Detectors	3.6.2.1, 3.6.2.2, 3.6.3.7, 3.6.4.5, 3.6.5.7
Flame detectors	3.6.4.5
Manual fire alarms	3.6.1.4
Power supplies	3.10.7.2
Pumps	5.18.5.2, Table 5-4
Receiving devices	3.10.5.2
Recording devices	3.10.6.2
Smoke detectors	3.6.3.7
Supervisory devices	3.7
Transmitters	3.10.4.7
Waterflow detectors	3.6.5.6
Tube, cathode ray (CRT)	2.2.1.2, 2.3.2.3, Figure 2-4
Tube, pitot	4.3.3, Figure 4-41
Turbine pump	4.3.3, Figures 4-39, 40, 44
Turbo type full registration meter	4.3.5.2, Figure 4-60

U

Ultraviolet detectors	2.2.3.2, 2.2.3.7, 3.6.4.2, 3.6.4.4, 3.6.4.5, Figure 3-21
UV/IR detectors	3.6.4.3, 3.6.4.4, 3.6.4.5
Unsupervised	
Circuit faults	3.5.3.3, Figure 3-10
Circuits	2.4.1.4, 3.5.4.1, Figures 2-34, 3-10

V

Valve	
Indicator	3.7.1.1, 3.7.1.4, 3.7.1.5, 3.7.1.6, 4.3.4.2, Figures 4-52, 53
Position switches	3.7, Figures 2-13, 14, 18, 19, 20, 23, 3-26, 27
Pressure specifications	Table 5-3
Supervisory devices	3.7.1, 3.7.1.5, 3.7.1.6
Switch installations	Figures 3-26, 27
Valves	
Altitude	4.3.6.2, 5.18.7.4, Figures 4-63, 64
Check	4.1.2.1, 4.3.5.1, 5.7, 5.8, 5.18.7.1, Figures 4-9, 10, 54, 55, 56, 57
Control	4.3.4, 5.14, 5.18.6, 7, Figures 4-51, 52, 53, Table 7-1
Deluge	4.1.2.4, 4.1.2.7, 5.10, Figures 4-20, 21, 26
Dry pipe	4.1.2.2, 5.8, Figures 4-11, 12, 15, 17, Table 5-3
Float	4.3.6.1, Figure 4-62
Gate	4.3.4, 5.18.6.1, Figure 2-23
Indicator, post	4.3.4.2, Figure 4-52

V (continued)

Valves (continued)

Outside screw and yoke (OS&Y)	3.7.1.1, 3.7.1.5, 3.7.1.6, 4.3.4.2, Figures 2-13, 14, 3-26, 4-53
Post indicator	4.3.4.2, Figure 4-52
Pre-action	4.1.2.5, 5.10
Pressure regulating	4.3.6, Figures 4-62, 63, 64, 65, 66
Relief	4.3.3, 4.3.6.4, Figures 4-42, 66

Vane type

Switches	2.2.3.3, Figure 3-23
Waterflow detector	3.6.5.3, 3.6.5.6, 3.6.5.7, Figure 3-23

Vertical

Radiator heating	4.3.2.2, Figure 4-37
Turbine pump	4.3.3, Figures 4-39, 44

Visual

Alarm signals	2.2
Indicators	2.2.2.3, 3.3.9, 3.8.1

Voltage

Cell	Table 3-1
Control Unit	3.4.1.1, 3.4.1.2
Systems	2.2.1.3, 2.3.1.1

W

Wafer check valve	4.3.5.1, Figure 4-55
-------------------	----------------------

Walls, fire	12.3.2
-------------	--------

Water

Cooling	4.3.3.3, Figure 4-48
Deluge systems	4.1.2.4, Figure 4-19
Level supervisory devices	3.7.2, Figures 2-21, 22, 3-28
Mains	4.3, 5.18.1, Table 5-1
Motor alarm	4.1.4, Figure 4-28
Motor gong	2.2.3.3, 4.1.4, Figure 4-28
Spray nozzles	4.1.1.4, Figure 4-8
Sprinklers, foam	6.2.2.1, Figure 6-8
Supplies	4.3, 5.18
Suppression, rapid reaction	4.1.2.7
Tanks	4.3.2, 5.18.4, Figures 4-32, 33, 34, 35
Temperature	3.7.5.2, 3.7.5.3, 3.7.5.4, 4.3.2.2, Figure 3-28

Waterflow

Alarm	2.2.3.3, Table 5-1
Detectors	3.6.5, Figures 3-22, 23, 24, 25, Table 3-1
Meters	4.3.5.2, 5.18.7.2, Figures 4-57, 58, 59, 60, Table 5-1

Tests	Table 5-1
-------	-----------

Weighing device, cylinder	9.1.1, Figure 9-1
---------------------------	-------------------

Wet barrel fire hydrant	4.3.1.1, 5.18.2, Figure 4-30
-------------------------	------------------------------

Wet chemical systems	10, 11, Figure 10-3, Table 11-1
----------------------	---------------------------------

Wet pipe sprinkler systems	3.6.5.6, 4.1.2.1
----------------------------	------------------

Wet standpipe systems	4.2.2
-----------------------	-------

W (continued)

Wire pulling	3.5.5
Wires, telephone type	2.3.1.1
Wiring	3.3.10
Diagrams	3.2
Plant type	3.10.3.2, 3.10.3.4, 3.10.3.5
Telephone type	3.10.3.1
Wooden water tanks	5.18.4.2

Z

Zone annunciator lamps	3.8.1.1, 3.8.2.5, 3.8.2.6
Zoning, cross	6.4, 7.4.2, 9.3.2